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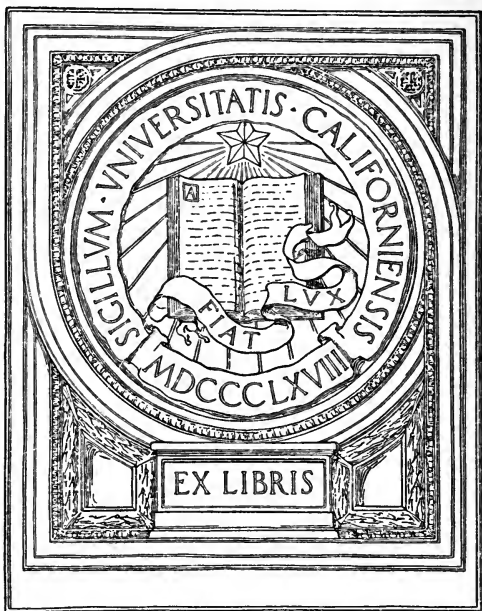


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PROBLEMS IN CHEMISTRY

MASTERSVILLE AND ESTABROOKE

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PROGRESSIVE PROBLEMS  
IN  
GENERAL CHEMISTRY

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*REVISED*

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## PREFACE

THE application of the principles of a science is the surest test of their understanding. The more thoroughly students are drilled with *Problems*, the surer is the teacher that his work has been worth while. To save time, and such is recognized as a distinct factor in modern pedagogy, problems from many sources have been brought together in this book. They have been taken from college examinations (American, European, and Australian), regents' examinations, College Entrance Examination Board papers, text books of all kinds, and such books dealing especially with chemical problems, arithmetic, or calculations as those of Thorpe, Tate, Foye, Waddell, Taylor, Miller, Hale, Dennis, Carpenter, Lupton, Talbot, etc. Many original problems have also been incorporated. If the student has successfully solved two hundred selected problems from this list, it may be safely said that he has acquired a fairly sound comprehension of the basic principles of chemistry.

No attempt is made to incorporate these principles, for they are gone into in the presentation of the subject, whatever text may be used or whatever method be pursued. A type series, however, is given in Chapter XIV. The number of problems is sufficiently great to admit of the use of the book a number of years before solutions of the problems may be handed down from one class to another.

It will be observed that the student must seek much necessary information from his text or such handy reference books as Biedermann's *Chemiker Kalendar* or Van Nostrand's *Chemical Annual* by Olsen. Our experience has shown good results accruing by having such reference books conveniently placed in each laboratory.

If the previous training of the student has been sound, consideration of Chapter I may be omitted; but it may be well to prove this by testing. It is a remarkable fact that college students, although they may know the metric system thoroughly, cannot think in its terms and are "up in the air" as soon as a question is propounded in meters, cubic centimeters, etc.

No attempt has been made to render the nomenclature uniform. The student thus has an opportunity to learn the various terms in good usage among English-speaking peoples, and he furthermore becomes more or less familiar with the everyday parlance among so-called practical men.

Our thanks are due Mrs. W. L. Estabrooke and Mr. E. A. Stevens, who assisted in collating. Mr. W. A. Hamor kindly followed the proofsheets.

## REVISED EDITION

Helpful suggestions on the part of many teachers have prompted us to incorporate much useful data in an appendix. All detected errors have been corrected and a booklet containing the answers to the problems has been prepared. This may be obtained by teachers on request to the publishers.

JUNE, 1911.

CHARLES BASKERVILLE.  
W. L. ESTABROOKE.

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# PROGRESSIVE PROBLEMS IN CHEMISTRY

## CHAPTER I

### Introduction

#### MEASUREMENT

##### *Metric System — Linear Measure*

1. Express 263.7018 m. as (a) dm.; (b) cm.; (c) mm.; (d) Dm.; (e) Hm.; (f) Km.
2. Express as m. (a) 5 Dm.; (b) 4 Hm.; (c) 9 Dm.; (d) 8 Km.; (e) 32 Hm.; (f) 360 cm.; (g) 630 mm.
3. How many mm. in (a) 13 Km.; (b) 92 Hm.; (c) 300 Dm.; (d) 26.91 m.; (e) 86.312 dm.; (f) 8 cm.?
4. In a mile how many Km.? How many m.? How many cm.?
5. Express 10 yd. in m.; in Km.; in Hm.; in cm.; in mm.
6. In 31.76 ft. how many m.? How many Km.? How many cm.? How many dm.?
7. Convert 83 in. into (a) mm.; (b) cm.; (c) Km.; (d) Hm.; (e) dm.
8. Find the value of the following expressions in m.:  
(a)  $0.435 \text{ m.} + 852 \text{ cm.} + 4263 \text{ mm.} + 0.159 \text{ Km.}$ ;  
(b)  $0.927 \text{ Km.} - 6495 \text{ cm., } 4.37 \text{ cm.} - 42.87 \text{ mm.}$ ;

- (c)  $8 \times 0.0457$  Km.,  $3.04 \times 60.93$  cm.,  $5.43 \times 67.2$  mm.;  
(d)  $38,019$  mm.  $\div 0.097$ ,  $0.14$  Km.  $\div 25.625$ .

9. A book is 2.1 cm. thick; if the average thickness of the leaves is 0.05 mm., find the number of pages in the book.

10. The cost of building a railroad is \$25,000 per Km.; what is the cost of the road, if its length is 72 Km. and 53 m.?

11. The wheels of a locomotive that make 45 Km. an hour are 7.5 m. in circumference; how many revolutions will they make a minute?

12. A train goes 1248 m. in  $1\frac{1}{2}$  min.; how many Km. will it go in 1 hr., 35 min., and 15 sec.?

13. The top of a monument is 143.9 m., and the base 67.19 m. above the level of the sea; the steps which lead from the base to the top of the monument are each 19 cm. high. How many steps are there?

14. Sound travels 1130 ft. per second; how many meters does it pass through per second?

15. It is 92,000,000 miles to the sun; how many Km. is it?

16. Light travels 186,000 miles per second; how many Km. per second is that?

17. The mean height of the barometer in the latitude of Greenwich at the level of the sea is 30 in.; to how many mm. is this equivalent?

18. How many dm. are equivalent to 106,725 mm.?

19. How many miles are there in 15 Km.?

20. In an English inch are contained 25.3995 mm.; how many Km. are there in a mile?

21. A nautical fathom is 6.087 ft.; what is its value in m.?

*Surface Measure*

22. Multiply 5 dm. by 3 mm., and give the answer in cm.

23. Reduce and give the answers to the following in  $\text{cm.}^2$ : (a)  $1.51 \text{ m.} \times 2.5 \text{ dm.}$ ; (b)  $0.35 \text{ m.} \times 3 \text{ cm.}$ ; (c)  $10 \text{ dm.}^2 \div 4 \text{ cm.}$ ; (d)  $1.3 \text{ m.}^2 \div 3 \text{ cm.}$

24. Measure the length and breadth of a sheet of paper and give the result in decimeters; then compute how many  $\text{cm.}^2$  could be cut from it.

25. Calculate the number of  $\text{cm.}^2$  contained on the surface of a filter paper having a radius of 5 cm.

26. A round filter paper is 10 cm. across; what is its area?

27. How many  $\text{cm.}^2$  are there in  $15.5 \text{ m.}^2$ ? How many  $\text{dm.}^2$  are contained in  $108,642 \text{ cm.}^2$ ?

28. Required the number of  $\text{mm.}^2$ ,  $\text{cm.}^2$ ,  $\text{dm.}^2$ , contained in the top of a table measuring  $1 \text{ m.} \times 70 \text{ cm.}$

29. Reduce the following to  $\text{cm.}^2$ : (a)  $2.8 \text{ dm.}^2$ ; (b)  $3.1 \text{ dm.}^2$ ; (c)  $1.35 \text{ m.}^2$ ; (d)  $0.75 \text{ dm.}^2$ ; (e)  $0.032 \text{ m.}^2$ ; (f)  $0.0064 \text{ dm.}^2$ ; (g)  $700 \text{ m.}^2$ .

30. Reduce the following to  $\text{dm.}^2$ : (a)  $53 \text{ cm.}^2$ ; (b)  $7.3 \text{ cm.}^2$ ; (c)  $0.003 \text{ cm.}^2$ ; (d)  $25 \text{ m.}^2$ ; (e)  $0.33 \text{ cm.}^2$ ; (f)  $28.03 \text{ m.}^2$ .

31. How many  $\text{cm.}^2$  in a square one side of which is (a)  $1.7 \text{ dm.}$ ; (b)  $35 \text{ dm.}$ ; (c)  $1 \text{ m.}$ ; (d)  $0.035 \text{ dm.}$ ; (e)  $3.2 \text{ dm.}$ ?

32. How many  $\text{cm.}^2$  in the following rectangles: (a)  $2 \text{ dm.} \times 6 \text{ cm.}$ ; (b)  $0.07 \text{ m.} \times 7 \text{ cm.}$ ; (c)  $3.2 \text{ dm.} \times 0.2 \text{ dm.}$ ; (d)  $58 \text{ dm.} \times 25 \text{ cm.}$ ?

33. Express  $1 \text{ mm.}^2$  as (a) the decimal of a  $\text{cm.}^2$ ; (b) of a  $\text{m.}^2$ ; (c) of a  $\text{dm.}^2$ .

34. Compute the area of a filter paper 12 cm. in diameter.  $\pi = 3.14$ .

35. Required the number of (a)  $\text{cm.}^2$ , (b)  $\text{dm.}^2$ , and (c)  $\text{m.}^2$  in 1,098,765,421  $\text{mm.}^2$ .

36. How many  $\text{m.}^2$  in 9  $\text{Dm.}^2$ ; 8  $\text{Hm.}^2$ ; 13  $\text{Km.}^2$ ?

37. How many ca. in 9 a.; in a Ha.?

38. What part of a Ha. is an a.; a ca.?

39. What part of a  $\text{m.}^2$  is a  $\text{dm.}^2$ ; a  $\text{mm.}^2$ ?

40. Convert 1,854,276  $\text{m.}^2$  into Ha.; into  $\text{Km.}^2$ .

41. Write 1.7431  $\text{m.}^2$  as  $\text{cm.}^2$ ; as  $\text{mm.}^2$ .

42. How many  $\text{Km.}^2$  in 17,467.5 Ha.?

43. How many  $\text{cm.}^2$  in 0.0137  $\text{m.}^2$ ?

44. Write 3.571  $\text{cm.}^2$  as  $\text{mm.}^2$ .

45. A man bought 3 Ha. of land at \$2.00 per Ha. and sold it for \$2.50 per a.; how much did he gain?

### *Volume*

46. A cellar 20 m.  $\times$  50 m.  $\times$  3 m. is to be excavated; what will it cost at 12 cents per  $\text{m.}^3$ ?

47. How many cc. are there in a block 12 cm. long, 8 cm. wide, and 5 cm. high?

48. How many  $\text{m.}^3$  are there in a wall 25 m. long, 8.4 m. high, and 76 cm. wide?

49. A wood pile contains 1800  $\text{m.}^3$ ; it is 15 m. long and 12 m. wide. How high is it?

50. How many  $\text{cm.}^2$  are there in one face of a cube containing 729 cc.?

51. A gallon is equal to 3.785 l.; how many cc. are contained in one pint?

52. Reduce 16 l. to U. S. gallons.

53. A beaker 6 cm. in diameter and 8 cm. high will hold how many l. of water?

54. A pneumatic trough is 3.1 dm. long by 1.9 dm. wide and 1.5 dm. high. (a) How many l. of water will it hold? (b) How many dl. of water? (c) How many cl.? (d) How many ml.?

55. A cistern 1.42 m.  $\times$  8.4 dm.  $\times$  53 cm. will hold what weight and volume of water?

56. A box is 1.2 dm.  $\times$  7 cm.  $\times$  30 mm. What is the capacity in cc.; also in l.?

57. Compute the contents of these boxes in l. and in cc.: (a) 12 cm.  $\times$  5 cm.  $\times$  4 cm.; (b) 2.1 dm.  $\times$  3.2 dm.  $\times$  10 cm.; (c) 1.04 m.  $\times$  1.03 m.  $\times$  1.02 m.

58. How many cc. in a slab of marble 1.5 m.  $\times$  7 dm.  $\times$  9 cm.? How many l. of water will such a slab displace?

59. Reduce the following to cc.: (a) 3.7 dm.<sup>3</sup>; (b) 5.02 dm.<sup>3</sup>; (c) 1.001 dm.<sup>3</sup>; (d) 0.003 dm.<sup>3</sup>; (e) 200 mm.<sup>3</sup>.

60. Reduce and express the following as indicated: (a) 2 dm.<sup>3</sup> to mm.<sup>3</sup>; (b) 5.7 dm.<sup>3</sup> to mm.<sup>3</sup>; (c) 33.33 cm.<sup>3</sup> to m.<sup>3</sup>; (d) 1.07 dm.<sup>3</sup> to m.<sup>3</sup>.

61. A stick of timber 4 m. long and 3 dm. wide has a solid contents of 240 dm.<sup>3</sup>; what is its thickness?

62. What is the capacity in l. of a rectangular tank 2 m. long, 9 dm. wide, and 8 dm. deep?

63. What is the volume of a spherical glass bulb which has a radius of 3 cm.?

64. How many l. of air are contained in a room measuring 4 m.  $\times$  3 m.  $\times$  2 m.?

65. In 1.5 pints there are how many cc.? How many mm.<sup>3</sup>?

66. How many l. of water are contained in a tank 3 m.  $\times$  1.6 m.  $\times$  1.4 m.?

67. How many Hl. in a bin 4 m.  $\times$  2 m.  $\times$  1 m.?

68. How high must a box be to hold 30 l. if it is 50 cm. long and 20 cm. wide?

69. In a m.<sup>3</sup>, how many dm.<sup>3</sup>; cc.<sup>3</sup>? What part of a m.<sup>3</sup> is a dm.<sup>3</sup>; a cc.<sup>3</sup>?

70. How many m.<sup>3</sup> in a rectangular box 125 cm.  $\times$  112 cm.  $\times$  80 cm.? How many l.?

71. How deep must a cistern be to hold 6000 l. if the bottom is a square measuring 2.25 m. on a side?

72. How many m.<sup>3</sup> of earth must be removed to dig a ditch 90 m.  $\times$  85 cm.  $\times$  50 cm.?

73. A cistern is 2 m.  $\times$  1.5 m.  $\times$  1 m.; how many l. of water will it hold?

74. A cylinder of a steam engine is 3 ft. in diameter and 5 ft. long; how many dm.<sup>3</sup> of steam will it contain?

### *Weight*

75. How many g. in 1 Kg.; 8 Dg.; and 6 Hg.? What part of 1 g. is 1 cg.; 1 dg.; 1 mg.?

76. In a ton how many Kg.? How many g.?

77. A Hl. of water weighs how many Kg.? What part of a ton?

78. Change 0.546 Kg. to g.; to mg.; to cg.

79. Change 0.391 of a ton to Kg.

80. How many cg. are contained in 2.567 Kg.? How many g. are contained in 1.725 Kg.?

81. How many cg. are contained in 2.567 Kg.? How many mg. are contained in 5 cc. of water at  $+4^{\circ}\text{C}.$ ?

82. How many mg. are there in 0.9 dg.? How many in 1 Kg.?

83. A cylindrical tube 90 mm. in length holds 1 g. of water at  $+4^{\circ}\text{C}.$  Calculate its internal diameter.

84. What is the weight of water in a tank 1.3 m.  $\times$  80 cm.  $\times$  250 mm.?

85. How many g. of water in a bottle containing 0.391 l.?

86. A sample of water contains 4 g. of solid matter per l.; to how many g. per gallon does this correspond?

87. A tank measures 2.5 m.  $\times$  3 m.  $\times$  6 m.; how many l. of water will it hold? How many Kg.?

88. A ton equals 1016.05 Kg.; how many g. in 1 lb. avoirdupois?

89. A piece of platinum foil measuring 10.5 cm. by 1.5 cm. weighs 0.723 g.; into how many pieces, each weighing 1 dg., may it be divided?

90. A fine wire 255 mm. in length weighs 0.172 g.; what length of such wire would it take to make a g. "rider"?

91. How much space will 3.750 g. of water occupy?

92. A piece of Swedish filter paper measuring 60 cm.<sup>2</sup> leaves on burning 0.1062 g. of ash. Calculate the amount of ash left on burning filters possessing the following radii: (a) 3 cm.; (b) 4 cm.; (c) 5 cm.; (d) 6 cm.; (e) 8 cm.; (f) 10 cm.

93. Required the number of mg. in 115 cc. of water measured at  $+4^{\circ}\text{C}$ .

94. A silver coin weighs 30 g.; what volume of water will it balance?

95. A piece of platinum foil is 5.2 cm.  $\times$  0.7 cm. and weighs 0.8 g.; into how many pieces, each weighing  $1\frac{1}{2}$  dg., may it be cut?

96. What weight of water is required to fill a vat 98 cm.  $\times$  71 cm.  $\times$  38 cm.?

97. A mass of 21.7 g. is divided into 70 pills; what is the weight of each pill?

98. At 2 cents a Kg., what will 2.25 tons of hay cost?

99. At \$6 a ton for coal, what will it cost to heat a building 30 days if it takes 400 Kg. of coal a day?

100. Into how many pieces of 325 mg. each may a mass of 23.4 g. be divided?

101. A liter of mercury weighs 13 Kg. 598 g.; find the weight in Kg. of 3.69 l.

102. If 16.94 l. of olive oil weigh 15 Kg. 500 g., find the weight of 1 l.

### *Thermometry*

103. What temperature on the C. scale is equivalent to  $+250^{\circ}\text{F}$ .?

104. What temperature C. corresponds to  $-250^{\circ}\text{F}$ .?

105. Change  $0^{\circ}\text{F}$ . to  $0^{\circ}\text{C}$ .

106. Express  $+40^{\circ}\text{C}$ . on the Fahrenheit scale.

107. Convert the following temperatures to  $\text{C}^{\circ}$ :

$+40^{\circ}\text{F}$ .,	$+2100^{\circ}\text{F}$ .,	$-70^{\circ}\text{F}$ .,
$-40^{\circ}\text{F}$ .,	$-28^{\circ}\text{F}$ .,	$+2700^{\circ}\text{F}$ .



**108.** Express the following temperatures in  $F.^{\circ}$  :

$$\begin{array}{lll} +125^{\circ} C., & +60^{\circ} C., & +312^{\circ} C., \\ +15^{\circ} C., & +480^{\circ} C., & -273^{\circ} C. \end{array}$$

**109.** A Fahrenheit thermometer, immersed in a certain hot fluid, rises through  $+50^{\circ}$ ; through how many degrees would a Centigrade thermometer have risen under the same circumstances?

**110.** What is the difference in temperature between  $+72^{\circ} C.$  and  $+72^{\circ} F.$ ?

**111.** What temperature on the Centigrade scale is equal to  $+212 F.$ ?

**112.** Express the following temperatures in  $C.^{\circ}$  :

$$\begin{array}{lll} +60^{\circ} F., & -15.5^{\circ} F., & +0.2^{\circ} F. \\ +10^{\circ} F., & +500^{\circ} F., & \end{array}$$

**113.** Express the following temperatures in  $F.^{\circ}$  :

$$\begin{array}{lll} +4^{\circ} C., & +60^{\circ} C., & +212^{\circ} C., \\ +15.5^{\circ} C., & +0.1^{\circ} C., & +1^{\circ} C. \end{array}$$

**114.** Reduce the following Centigrade degrees to the Absolute scale :

$$\begin{array}{l} +37^{\circ} C., +26^{\circ} C., +273^{\circ} C., +11^{\circ} C., -12^{\circ} C., \\ +55^{\circ} C., +18^{\circ} C., +40^{\circ} C., -40^{\circ} C. \end{array}$$

**115.** Reduce the following Fahrenheit degrees to the Absolute scale :

$$+25^{\circ} F., +60^{\circ} F., +1^{\circ} F., -8^{\circ} F., -30^{\circ} F.$$

**116.** Reduce the following Fahrenheit temperatures to the Centigrade scale :

$$\begin{array}{l} +68^{\circ} F., +36^{\circ} F., +30^{\circ} F., +32^{\circ} F., 0^{\circ} F., -40^{\circ} F., \\ -44^{\circ} F., -36^{\circ} F., +10^{\circ} F., -10^{\circ} F., -1^{\circ} F. \end{array}$$

**117.** Reduce the following Centigrade degrees to Fahrenheit:

+ 72° C., + 36° C., 0° C., + 4° C., - 4° C., - 40° C.,  
+ 40° C., - 273° C., + 273° C., - 1° C., + 1° C.

**118.** What must be the temperature of a liquid so that both the Fahrenheit and Centigrade thermometers shall read the same when immersed in it?

**119.** Reduce + 8° C., + 20° C., + 70° C., - 40° C., and + 10° C. to the Fahrenheit scale.

**120.** Reduce + 8° F., + 40° F., + 180° F., - 10° F., and + 36° F. to the Centigrade scale.

**121.** Change these to the Absolute scale:

+ 79° F., + 79° C., + 31° C., - 60° C., - 5° C.

**122.** Sulphuric acid boils at + 338° C.; what is the corresponding boiling point on Fahrenheit's scale?

**123.** Cast iron melts at + 2822° F. and tin at + 455° F.; what is the difference between their melting points expressed in Centigrade degrees?

**124.** Bromine boils at + 138.7° F.; what is the corresponding temperature on the Centigrade scale?

**125.** Absolute zero is 273° below zero on the Centigrade scale; what is this temperature on the Fahrenheit scale?

**126.** Iron melts at + 1200° C.; what is the melting point on the Fahrenheit scale?

**127.** The average difference in temperature between two places is + 60° F.; how much would this be on the Centigrade scale?

**128.** A low artificial temperature obtained is - 140° C.; what is the corresponding temperature in F. degrees?

**129.** Chloroform boils at  $+61.2^{\circ}\text{C.}$ , turpentine boils at  $+156^{\circ}\text{C.}$ , and glycerine boils at  $+290^{\circ}\text{C.}$ ; what are the Fahrenheit readings?

**130.** At a certain temperature C. scale the reading is as much below  $0^{\circ}\text{C.}$  as it is above on the F. scale. Find the readings.

**131.** Ether boils at  $+34.5^{\circ}\text{C.}$ , alcohol at  $+78.4^{\circ}\text{C.}$ , and sulphuric acid at  $+338^{\circ}\text{C.}$ ; what are the corresponding boiling points on Fahrenheit's scale?

**132.** Mercury freezes at  $-40^{\circ}\text{C.}$  and boils at  $+350^{\circ}\text{C.}$  Calculate the corresponding temperatures on the scales of Réaumur and Fahrenheit.

**133.** Cast iron melts at  $+1075^{\circ}\text{C.}$ , zinc at  $+423^{\circ}\text{C.}$ , lead at  $+324^{\circ}\text{C.}$ , tin at  $+235^{\circ}\text{C.}$  Calculate these temperatures in F. degrees.

**134.** The difference between readings on C. and F. scale is 64. Find the reading.

### *Specific Gravity of Solids and Liquids*

**135.** A piece of metal weighs 24.076 g. in air and 21.2436 g. in water; what is its sp. gr.?

**136.** A piece of mineral weighs 47 g. in air and 36.555 g. in water; what is its sp. gr.?

**137.** A piece of iron ore weighs 27 g. in air and 21.6 g. in water; what is its sp. gr.?

**138.** A certain fine powder weighs in the air 7 g.; when this powder is placed in a flask, and this flask is then filled with water to a mark on the flask, the weight of the flask, powder, and water to the mark is 59 g. The weight of the flask filled with water only to the mark is 55 g. What is the sp. gr. of the insoluble powder?

**139.** A certain fine sand weighs 12 g. in the air. A flask filled with water to mark weighs 47.6 g. The same flask containing the sand and filled to the same mark with water weighs 56.5 g. What is the sp. gr. of the sand?

**140.** An empty bottle weighing 3.5305 g. weighs when filled with pure water 7.6722 g., when filled with seawater 7.7849 g. What is the sp. gr. of sea water?

**141.** A sample of sugar weighs 7.5 g. in the air and 4.6 g. in petroleum ether of sp. gr. 0.64; what is the sp. gr. of the sugar?

**142.** Find the sp. gr. of common salt from the following data: weight of salt in air, 8.85 g.; weight of flask and turpentine to mark, 45.24 g.; weight of flask, salt, and turpentine to mark, 50.56 g.; sp. gr. of turpentine, 0.86 g.

**143.** Find the relative densities of the following substances:

	Granite	Marble	Hematite
Weight in air	409.82 g.	53.2841 g.	13.6287 g.
“ “ water	259.31 g.	33.4020 g.	10.9406 g.

**144.** A sp. gr. flask holds 2.545 mg. of alcohol, 42.740 of mercury, and 5.829 of sulphuric acid. Calculate the relative density of the sulphuric acid and mercury, the density of the alcohol being 0.80.

**145.** A solid weighs in a vacuum 100 g.; in water 85 g.; and in another liquid 88 g. What is the relative density of this liquid?

**146.** Determine the relative density of gold from the following data:

Weight of gold in air	4.6764 g.
Loss of weight in water	0.2447 g.

**147.** A glass rod weighing 13 g. in air weighs 8 g. in water and 3.8 g. in sulphuric acid; what is the sp. gr. of the sulphuric acid?

**148.** A piece of iron sulphide weighed in air 4.8934 g. ; in water it weighed 3.8860 g. Calculate its relative density.

**149.** Find the weight of a block of sulphur 50 m.<sup>3</sup> in volume and of relative density 2.05.

**150.** What is the weight of 1 l. of bromine, sp. gr. 3.19; of burning oil, sp. gr. 0.83; of alcohol, sp. gr. 0.80; of mercury, sp. gr. 13.59?

**151.** What is the volume of 1 Kg. of iron, sp. gr. 7.85; of magnesium, sp. gr. 1.74; of platinum, sp. gr. 21.5; of ice, sp. gr. 0.92?

**152.** A bottle holds 336 g. of water; it also holds 577.9 g. of sulphuric acid. What is the sp. gr. of the acid?

**153.** A bottle weighs 80 g. when empty. Filled with water it weighs 230 g. Filled with bromine it weighs 560 g.; with hydrochloric acid, 260 g. What is the sp. gr. of the bromine and of the acid? What is the capacity of the bottle?

**154.** A bar of gold measures 34 by 10.5 by 11 cm., and weighs 75.87 Kg.; what is the sp. gr. of the gold?

**155.** A block of wood measures 49.8 by 60.5 by 210 cm.; its sp. gr. is 0.63. What is the weight of the block?

**156.** What is the weight of a m.<sup>3</sup> of bromine, sp. gr. 3.19; of water at +4° C.; of sulphuric acid, sp. gr. 1.84?

**157.** The sp. gr. of  $\text{HNO}_3$  is 1.52. (a) Find weight of 20 cc.; (b) 87 cc.; (c) how many cc. in 100 g.?

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**158.** What is the weight of 40 cc. of sulphuric acid having a sp. gr. of 1.84?

**159.** What is the volume of 3.6 Kg. of alcohol having a sp. gr. of 0.80?

**160.** A piece of metal weighs 3.7395 g. in air, 1.578 g. in water, and 2.2896 g. in another liquid; what is the sp. gr. of the metal and of the liquid?

**161.** A piece of platinum foil 14.2 cm. long and 2.5 mm. broad weighs 12 g.; find the thickness. Density of platinum = 21.5.

**162.** A body weighing 18.5 g. when under water weighs 16.4 g. and when in naphtha 16.72 g.; what is the sp. gr. of the naphtha?

**163.** Find the mass of 1 m.<sup>3</sup> iron. Sp. gr. Fe = 7.80.

**164.** A mercury barometer stands at 76.1 mm.; what would be the reading on a glycerine barometer? Sp. gr. glycerine is 1.26, mercury is 13.59.

**165.** Nitric acid being 1.52 times as heavy as water, what is the weight of 1 l. of the acid?

**166.** A piece of sodium weighed 14.1563 g. in dry air and 2.1807 g. in kerosene of sp. gr. 0.83; what is the sp. gr. of sodium?

**167.** A piece of metal weighs 47 g. in water and 48.756 g. in petroleum ether of sp. gr. 0.66; what is the sp. gr. of the metal?

**168.** A piece of brass weighs 10 g. in air, 8.824 g. in water, and 9 g. in turpentine. Calculate the sp. gr. of the turpentine.

**169.** If sulphuric acid has a sp. gr. of 1.84, how many cc. of it will weigh 80 g.?

**170.** A block of marble 5 cm.  $\times$  4 cm.  $\times$  3 cm. has a sp. gr. of 2.7; how many g. will it weigh?

**171.** A lump of sodium carbonate (sp. gr. = 1.45) is 65 mm.  $\times$  .4 dm.  $\times$  3 cm.; what does it weigh?

**172.** The sp. gr. of sulphuric acid is 1.84. A carboy holds 5 gal. of 231 in.<sup>3</sup> each. How heavy would the contents of this carboy be?

**173.** What is the density of a cube of oak 9 mm. along each edge and which weighs 0.62 g.?

**174.** A cylinder of mahogany 10.1 cm. high and 9.4 cm. across weighs 405.7 g. Find its density.

**175.** A block of steel (sp. gr. = 7.6) is 10 cm. square and 1.8315 cm. thick. Find the mass of it in g.

**176.** What is the mass of a m.<sup>3</sup> of hematite (sp. gr. = 5.25)?

**177.** Find the volume of 1000 g. of sea water (sp. gr. = 1.03).

**178.** Find the mass of a m.<sup>3</sup> of anthracite (sp. gr. = 1.4).

**179.** How many tons does a block of granite (sp. gr. = 2.7) 10  $\times$  3  $\times$  2 m. weigh?

**180.** If a glass ball weighing 7.7158 g. 2 cm. in diameter just floats in a liquid, find the sp. gr. of the liquid.

**181.** What is the density of  $K_2Cr_2O_7$ , if 6.2138 g. of it displace 2.0532 g. of benzene (sp. gr. = 0.88)?

## CHAPTER II

### Molecular Weights from Atomic Weights

#### MOLECULAR WEIGHTS

Calculate the molecular weights of the following:

1.  $\text{HC}_2\text{H}_3\text{O}_2$ ;  $\text{AlBr}_3$ ;  $\text{Al}_4\text{C}_3$ ;  $\text{Al}_2\text{O}_3$ ;  $\text{AlI}_3$ ;  
 $\text{Al}(\text{NO}_3)_3$ ;  $\text{AlPO}_4$ ;  $\text{Al}_2(\text{SO}_4)_3$ ;  $\text{K}_2\text{Al}_2(\text{SO}_4)_4, 24 \text{ H}_2\text{O}$ .

2.  $\text{NH}_4\text{Cl}$ ;  $(\text{NH}_4)_2\text{CO}_3$ ;  $\text{NH}_4\text{HCO}_3$ ;  $(\text{NH}_4)_2\text{CrO}_4$ ;  
 $\text{NH}_4\text{CN}$ ;  $\text{NH}_4\text{F}$ ;  $(\text{NH}_4)_2\text{MoO}_4$ ;  $\text{NH}_4\text{NO}_3$ ;  $\text{NH}_4\text{NO}_2$ .

3.  $\text{NH}_4\text{ClO}_4$ ;  $\text{NH}_4\text{H}_2\text{PO}_4$ ;  $(\text{NH}_4)_2\text{S}$ ;  $\text{NH}_4\text{CNS}$ ;  
 $(\text{NH}_4)_2\text{W}_4\text{O}_{13}, 8 \text{ H}_2\text{O}$ .

4.  $\text{SbBr}_3$ ;  $\text{SbH}_3$ ;  $\text{Sb}_2\text{O}_3$ ;  $\text{SbOCl}$ ;  $\text{Sb}_2\text{S}_3$ ;  
 $\text{H}_3\text{AsO}_4$ ;  $\text{As}_2\text{O}_3$ .

5.  $\text{AuCl}_3$ ;  $\text{Au}_2\text{O}_3$ ;  $\text{Au}_2\text{S}_3$ ;  $\text{AuBr}_3$ ;  $\text{Au}_2\text{O}$ ;  
 $\text{Ba}(\text{C}_2\text{H}_3\text{O}_2)_2, \text{H}_2\text{O}$ ;  $\text{BaCO}_3$ .

6.  $\text{BaCrO}_4$ ;  $\text{BaF}_2$ ;  $\text{BaSO}_4$ ;  $\text{BiBr}_3$ ;  $\text{BiONO}_3$ ;  
 $\text{Bi}_2\text{S}_3$ ;  $\text{H}_3\text{BO}_3$ ;  $\text{B}_6\text{C}$ .

7.  $\text{BrCl}, 10 \text{ H}_2\text{O}$ ;  $\text{CdSO}_4$ ;  $\text{CdO}$ ;  $\text{CdS}$ ;  $\text{Cd}(\text{NO}_3)_2$ ;  
 $\text{Cd}(\text{CN})_2$ ;  $\text{CdWO}_4$ ;  $\text{CsCl}$ ;  $\text{CsBr}$ ;  $\text{Cs}_2\text{S}_5$ .

8.  $\text{CaCO}_3$ ;  $\text{CaAl}_2\text{O}_4$ ;  $\text{Ca}(\text{HCO}_3)_2$ ;  $\text{CaO}$ ;  
 $\text{Ca}(\text{ClO}_3)_2$ ;  $\text{CaF}_2$ ;  $\text{Ca}(\text{OH})_2$ ;  $\text{CaI}_2$ ;  $\text{CaSO}_4$ ;  $\text{CO}_2$ .

9.  $\text{C}_2\text{Br}_4$ ;  $\text{C}_2\text{Cl}_4$ ;  $\text{CS}_2$ ;  $\text{CO}$ .

10.  $\text{CeC}_2$ ;  $\text{Ce}(\text{NO}_3)_4$ ;  $\text{CeO}_2$ ;  $\text{CeCl}_3$ ;  $\text{Cl}_2\text{O}$ ;  $\text{Cl}_2\text{O}_7$ ;  
 $\text{CrO}_3$ ;  $\text{CrCl}_3$ ;  $\text{Cr}_2(\text{SO}_4)_3$ .



11.  $\text{CrO}_2\text{Cl}_2$ ;  $\text{Co}_2\text{P}$ ;  $\text{CoCl}_2$ ;  $\text{Co}(\text{NH}_3)_6\text{Cl}_3$ ;  $\text{Co}(\text{OH})_3$ ;  $\text{CbBr}_5$ ;  $\text{CbH}$ ;  $\text{CbN}$ ;  $\text{Cb}(\text{HC}_2\text{O}_4)_5$ ;  $\text{CbOBr}_3$ ;  $\text{Cb}_2\text{OS}_3$ .

12.  $\text{CuBr}_2$ ;  $\text{Cu}_2\text{O}$ ;  $\text{CuSO}_4, 5 \text{H}_2\text{O}$ ;  $\text{CuCO}_3$ ;  $\text{CNOH}$ ;  $\text{C}_2\text{N}_2$ ;  $\text{ErCl}_3, 6 \text{H}_2\text{O}$ ;  $\text{Er}_2\text{O}_3$ ;  $\text{Er}_2(\text{SO}_4)_3$ .

13.  $\text{FeAsO}_4, 2 \text{H}_2\text{O}$ ;  $\text{FeCl}_2$ ;  $\text{FeCl}_3$ ;  $\text{FeCO}_3$ ;  $\text{Fe}_3\text{O}_4$ ;  $\text{FeS}$ .

14.  $\text{Ga}_2(\text{SO}_4)_3$ ;  $\text{Ga}_2\text{S}_3$ ;  $\text{GeBr}_4$ ;  $\text{GeOCl}_2$ ;  $\text{BeCO}_3$ ;  $\text{BeF}_2$ .

15.  $\text{Au}_2\text{P}_3$ ;  $\text{NH}_2\text{NH}_2$ ;  $\text{HCl}$ ;  $\text{HCN}$ ;  $\text{H}_2\text{O}_2$ ;  $\text{NH}_2\text{OH}$ ;  $\text{InBr}_3$ ;  $\text{InCl}_3$ .

16.  $\text{In}(\text{CN})_3$ ;  $\text{HIO}_3$ ;  $\text{ICl}$ ;  $\text{IrI}_3$ ;  $\text{IrS}_2$ ;  $\text{Fe}_3\text{C}$ ;  $\text{LaC}_2$ ;  $\text{La}_2\text{O}_3$ ;  $\text{La}_2(\text{SO}_4)_3$ ;  $\text{La}_2\text{S}_3$ .

17.  $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$ ;  $\text{Pb}(\text{BO}_2)_2, \text{H}_2\text{O}$ ;  $\text{PbBr}_2$ ;  $\text{Pb}(\text{NO}_3)_2$ ;  $\text{PbO}$ ;  $\text{Pb}_3\text{O}_4$ .

18.  $\text{PbO}_2$ ;  $\text{LiBr}$ ;  $\text{LiOH}$ ;  $\text{LiNO}_3$ ;  $\text{Li}_2\text{C}_2\text{O}_4$ ;  $\text{Li}_2\text{O}$ ;  $\text{MgCO}_3$ .

19.  $\text{MgF}_2$ ;  $\text{MgSO}_4, 7 \text{H}_2\text{O}$ ;  $\text{MnCl}_2$ ;  $\text{Mn}(\text{OH})_2$ ;  $\text{HgCl}_2$ ;  $\text{HgSO}_4$ .

20.  $\text{HgCl}$ ;  $\text{HgS}$ ;  $\text{MoC}$ ;  $\text{MoCl}_3$ ;  $\text{MoS}_2$ ;  $\text{NdCl}_3, 6 \text{H}_2\text{O}$ ;  $\text{NdC}_2$ .

21.  $\text{NiAs}$ ;  $\text{Ni}(\text{C}_2\text{H}_3\text{O}_2)_2$ ;  $\text{NiCO}_3$ ;  $\text{HNO}_3$ ;  $\text{N}_2$ ;  $\text{N}_2\text{O}$ ;  $\text{NOCl}$ .

22.  $\text{OsCl}_2$ ;  $\text{OsO}_4$ ;  $\text{OsS}_2$ ;  $\text{O}_2$ ;  $\text{PdBr}_2$ ;  $\text{Pd}(\text{CN})_2$ ;  $\text{PdSO}_4, 2 \text{H}_2\text{O}$ .

23.  $\text{PF}_3$ ;  $\text{PBr}_2\text{N}$ ;  $\text{Pt}_2\text{O}_3$ ;  $\text{PtBr}_2$ ;  $\text{K}_2\text{Al}_2\text{O}_4, 3 \text{H}_2\text{O}$ ;  $\text{K}_2\text{PtCl}_4$ ;  $\text{KOH}$ ;  $\text{PrCl}_3$ .

24.  $\text{Pr}_2\text{S}_3$ ;  $\text{RaBr}_2$ ;  $\text{RaCl}_2$ ;  $\text{RhCl}_3$ ;  $\text{Rh}(\text{SH})_3$ ;  $\text{Rh}(\text{OH})_3$ ;  $\text{RbBr}$ ;  $\text{Rb}_2\text{CO}_3$ ;  $\text{RbF}$ ;  $\text{RbOH}$ .

25.  $\text{RuCl}_2$ ;  $\text{Ru}(\text{OH})_3$ ;  $\text{Ru}_2\text{O}_3$ ;  $\text{SmC}_2$ ;  $\text{Sm}(\text{NO}_3)_3$ ,  
6  $\text{H}_2\text{O}$ ;  $\text{Sc}_2\text{O}_3$ .

26.  $\text{Sc}_2(\text{SO}_4)_3$ ;  $\text{Se}_2\text{Br}_2$ ;  $\text{SeCl}_2$ ;  $\text{SeOCl}_2$ ;  $\text{SiHBr}_3$ ;  
 $\text{SiF}_4$ .

27.  $\text{AgC}_2\text{H}_3\text{O}_2$ ;  $\text{AgBrO}_3$ ;  $\text{AgCl}$ ;  $\text{Ag}_2\text{Se}$ ;  $\text{Ag}_2\text{S}$ ;  
 $\text{NaCl}$ ;  $\text{Na}_2\text{SO}_4$ .

28.  $\text{NaNO}_3$ ;  $\text{NaHCO}_3$ ;  $\text{NaAuCl}_4$ , 2  $\text{H}_2\text{O}$ ;  $\text{Na}_3\text{VO}_4$ ,  
16  $\text{H}_2\text{O}$ ;  $\text{Na}_2\text{WO}_4$ , 2  $\text{H}_2\text{O}$ .

29.  $\text{SnO}_2$ ;  $\text{Sn}_2\text{Fe}(\text{CN})_6$ ;  $\text{SnF}_2$ ;  $\text{SrBr}_2$ ;  $\text{SrC}_2$ ;  
 $\text{Sr}(\text{BrO}_3)_2$ ,  $\text{H}_2\text{O}$ ;  $\text{H}_2\text{SO}_4$ ;  $\text{SOBr}_2$ ;  $\text{TaBr}_5$ .

30.  $\text{Ta}_2\text{O}_5$ ;  $\text{H}_2\text{C}_4\text{H}_4\text{O}_6$ ;  $\text{TeO}_2$ ;  $\text{Tb}_2\text{O}_3$ .

31.  $\text{TlF}$ ;  $\text{TlOH}$ ;  $\text{Tl}(\text{NO}_3)_3$ ;  $\text{ThBr}_4$ ;  $\text{Th}(\text{C}_2\text{O}_4)_2$ ;  
 $\text{Ti}_5(\text{CN})_4$ ;  $\text{Ti}_2\text{O}_3$ .

32.  $\text{WBr}_2$ ;  $\text{W}_2\text{C}$ ;  $\text{WCl}_4$ ;  $\text{WO}_2$ ;  $\text{H}_2\text{WO}_4$ ;  $\text{H}_2\text{UO}_4$ ;  
 $\text{U}_2\text{C}_3$ .

33.  $\text{UO}_2\text{Cl}_2$ ;  $\text{HVO}_3$ ;  $\text{VF}_3$ , 3  $\text{H}_2\text{O}$ ;  $\text{Yb}(\text{C}_2\text{H}_3\text{O}_2)_3$ ,  
2  $\text{HO}_2$ ;  $\text{Yb}_2\text{O}_3$ ;  $\text{Yb}_2(\text{SO}_4)_3$ ;  $\text{YtBr}_3$ ;  $\text{Yt}(\text{NO}_3)_3$ ,  
4  $\text{H}_2\text{O}$ .

34.  $\text{ZnF}_2$ ;  $\text{Zn}_2\text{Fe}(\text{CN})_6$ , 3  $\text{H}_2\text{O}$ ;  $\text{ZnSO}_4$ , 6  $\text{H}_2\text{O}$ ;  
 $\text{ZrBr}_4$ ;  $\text{Zr}(\text{OH})_4$ ;  $\text{ZrOCl}_2$ , 8  $\text{H}_2\text{O}$ ;  $\text{Zr}(\text{SO}_4)_2$ , 4  $\text{H}_2\text{O}$ .

35. What are the molecular weights of the minerals  
having the following formulas:  $(\text{Ag}_2\text{Pb})\text{Se}$ ;  $(\text{AgCu})_2\text{S}$ ;  
 $\text{Cu}_2\text{Se}$ ;  $(\text{PbHg}_2)\text{Se}$ ;  $(\text{PbCuAg}_2)\text{Se}$ ;  $\text{Hg}(\text{SSe})$ ;  
 $(\text{HgZn})\text{S}$ ;  $\text{NiSb}$ .

36.  $\text{Ni}(\text{SbAs})$ ;  $\text{Fe}_{16}\text{S}_{16}$ ;  $\text{CoS}_2$ ,  $\text{CoAs}$ ;  $\text{PtAs}_2$ ;  
 $\text{RuS}_2$ ;  $\text{FeS}_2$ ,  $\text{FeAs}$ ;  $\text{NiS}_2$ ,  $\text{Ni}(\text{AsSb})_2$ ;  $\text{Cu}_2\text{S}$ ,  $\text{Bi}_2\text{S}_3$ ;  
 $\text{MnS}_2$ .

37. 9  $\text{Ag}_2\text{S}$ ,  $\text{Sb}_2\text{S}_3$ ;  $\text{Ag}(\text{ClBrI})$ ;  $(\text{FeMg})\text{O}$ ,  $\text{TiO}_2$ ;  
 $\text{MnO}$ ,  $\text{TiO}_2$ ;  $\text{MgO}$ ,  $\text{Al}_2\text{O}_3$ ;  $(\text{FeMg})\text{O}$ ,  $\text{Fe}_2\text{O}_3$ ;  $\text{FeO}$ ,  
 $\text{Cr}_2\text{O}_3$ .

38.  $\text{Mn}_2\text{O}_3, \text{H}_2\text{O}; (\text{CaBa})\text{CO}_3; \text{CaCO}_3, (\text{MgFe})\text{CO}_3;$   
 $\text{KAlSi}_3\text{O}_8; (\text{K}_2\text{Ba})\text{Al}_2\text{Si}_4\text{O}_{12}; (\text{NaK})\text{AlSi}_3\text{O}_8.$

39.  $\text{CaAlSi}_2\text{O}_8; \text{BaAl}_2\text{Si}_2\text{O}_8; \text{H}_2\text{Cs}_4\text{Al}_4(\text{SiO}_3)_9;$   
 $\text{NaFe}(\text{SiO}_3)_2; \text{HNaCa}_2(\text{SiO}_3)_3; (\text{MnZnFeCa})\text{SiO}_3.$

40.  $(\text{K}_2\text{Na}_2\text{MgCaMn})_4(\text{SiO}_3)_4; \text{NaAl}(\text{SiO}_3)_2,$   
 $(\text{FeMg})\text{SiO}_3; \text{K}_2\text{Na}_6\text{Al}_8\text{Si}_9\text{O}_{34};$   
 $(\text{NaK})_{10}\text{Ca}_4\text{Al}_{12}\text{Si}_{12}\text{O}_{52}\text{S}\text{Cl}_4.$

41.  $\text{Na}_4(\text{NaS}_3, \text{Al})\text{Al}_2(\text{SiO}_4)_3; \text{Bi}_4(\text{SiO}_4)_3;$   
 $\text{Ca}_3\text{Al}_2(\text{SiO}_4)_3; (\text{FeZnMn})_2[(\text{ZnFe})_2\text{S}]\text{Be}_3(\text{SiO}_4)_3;$   
 $\text{Ca}_3\text{Cr}_2(\text{SiO}_4)_3.$

42.  $\text{HCaBSiO}_5; \text{HBeAlSiO}_5; \text{Be}_2\text{Fe}(\text{YO})_2(\text{SiO}_4)_2;$   
 $(\text{CaFe})_2(\text{AlOH})(\text{AlCeFe})_2(\text{SiO}_4)_3; \text{CaB}_2(\text{SiO}_4)_2.$

43.  $[\text{Mg}(\text{FOH})]_2\text{Mg}_3(\text{SiO}_4)_2; (\text{Na}_2\text{Ca})\text{Al}_2\text{Si}_6\text{O}_{16},$   
 $6 \text{H}_2\text{O}; \text{CaAl}_2\text{Si}_3\text{O}_{10}, 5 \text{H}_2\text{O}; \left\{ \begin{array}{l} \text{Na}_2\text{Al}_2\text{Si}_3\text{O}_{10}, 2 \text{H}_2\text{O} \\ 2 [\text{CaAl}_2\text{Si}_3\text{O}_{10}, 3 \text{H}_2\text{O}]. \end{array} \right\}$

44.  $\text{H}_2\text{KAl}_3(\text{SiO}_4)_3; \text{KLi}[\text{Al}(\text{OHF})_2]\text{Al}(\text{SiO}_3)_3;$   
 $[\text{HK}(\text{MgFe})]_3\text{Mg}_3\text{Al}(\text{SiO}_4)_3; (\text{PbCl})\text{Pb}_4(\text{VO}_4)_3.$

45.  $(\text{MnOH})\text{MnAsO}_4; (\text{MgF})\text{MgPO}_4;$   
 $(\text{PbZn})_2(\text{OH})\text{VO}_4; (\text{PbZnCu})_2(\text{OH})\text{VO}_4;$   
 $\text{Zn}_3\text{As}_2\text{O}_8, 8\text{H}_2\text{O}.$

## CHAPTER III

### Percentage Composition

1. Find per cent of potassium in (a) KBr; (b)  $\text{KNO}_3$ ; (c)  $\text{K}_2\text{SO}_4$ ; (d)  $\text{K}_2\text{S}$ .

2. Calculate the percentage of oxygen by weight in mercuric oxide, manganese dioxide, potassium chlorate, and water.

3. In borax ( $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10 \text{H}_2\text{O}$ ) find the percentage (a) of B; (b) of Na; (c) of O; (d) of  $\text{H}_2\text{O}$ .

4. Calculate the percentage composition of  $\text{CaCO}_3$ ,  $\text{CaC}_2$ ,  $\text{CaCl}_2$ ,  $\text{CO}_2$ ,  $\text{MgCO}_3$ ,  $\text{Na}_2\text{CO}_3$ , and  $\text{CO}$ .

5. What is the per cent of tin in tinstone ( $\text{SnO}_2$ ), in  $\text{SnCl}_4$ , and in  $\text{SnCl}_2$ ?

6. Calculate the percentage composition of the following compounds :

Potassium ferrocyanide. . . .  $\text{K}_4\text{Fe}(\text{CN})_6 \cdot 3 \text{H}_2\text{O}$ .

Iso-creatine . . . . .  $\text{C}_4\text{H}_9\text{N}_3\text{O}_2$ .

Rosaniline . . . . .  $\text{C}_{20}\text{H}_{21}\text{N}_3\text{O}$ .

Strychnine . . . . .  $\text{C}_{21}\text{H}_{22}\text{N}_2\text{O}_2$ .

7. The skeleton of a man weighs 24 lb. and contains 58 per cent of calcium phosphate [ $\text{Ca}_3(\text{PO}_4)_2$ ]. Find the quantity of phosphorus present.

8. How much phosphorus can be obtained from 169 tons of bones containing 53.7 per cent of calcium phosphate?

9. Find the percentage composition of crystallized hydrogen disodium phosphate ( $\text{Na}_2\text{HPO}_4, 12 \text{H}_2\text{O}$ ).

10. Find the per cent by weight of the elements called for in the following: (a) per cent of oxygen in  $\text{HgO}$ ; (b) of hydrogen in  $\text{HCl}$ ; (c) of lead in  $\text{PbS}$ ; (d) of lead in  $\text{Pb}(\text{NO}_3)_2$ ; (e) of each element in  $\text{Ca}_3(\text{PO}_4)_2$ .

11. Find the percentage composition of  $\text{H}_3\text{PO}_4$  to one decimal place.

12. Find the percentage composition of ammonium nitrate.

13. A sample of copper salt weighing 0.9864 g. is dissolved in water and the copper deposited electrolytically. The weight of the electrode before passing the current was 9.8609 g.; at the end of the operation 10.1121 g. Find the per cent of copper in the sample.

14. Which is the richer in iron,  $\text{Fe}_2\text{O}_3$  (hematite) or  $\text{Fe}_3\text{O}_4$  (magnetite)? Compute.

15. Find the percentage composition of alcohol,  $\text{C}_2\text{H}_6\text{O}$ .

16. What per cent of sulphur is contained in pure pyrite?

17. Compute the percentage composition of  $\text{Fe}_3\text{O}_4$  to one decimal place.

18. Calculate the percentage of silica in potash mica ( $\text{KAlSiO}_4$ ).

19. What per cent of silicon is in quartz?

20. What per cent of magnesium is contained in crystallized potassium magnesium sulphate,  $\text{K}_2\text{SO}_4, \text{MgSO}_4, 6 \text{H}_2\text{O}$ ?

21. What weight of potassium can be obtained from 20 g. of alum  $[\text{K}_2\text{Al}_2(\text{SO}_4)_4, 24 \text{H}_2\text{O}]$  ?

22. Find the percentage composition of bleaching powder if its formula is  $\text{Ca}(\text{OCl}_2)$ .

23. 100 g. of each variety of sodium carbonate—  
(a)  $\text{Na}_2\text{CO}_3, 10 \text{H}_2\text{O}$ ; (b)  $\text{Na}_2\text{CO}_3, 8 \text{H}_2\text{O}$ ; (c)  $\text{Na}_2\text{CO}_3, 5 \text{H}_2\text{O}$ ; (d)  $\text{Na}_2\text{CO}_3, \text{H}_2\text{O}$ —contain how many g. of water ?

24. What is the percentage of (a) barium oxide in witherite; (b) strontium oxide in strontianite; (c) zinc oxide in calamine ?

25. Calculate the percentage composition of the following compounds: carbon dioxide; ammonia; ferric oxide; acetic acid; calcium sulphate; cream of tartar; ferrous sulphate; common alum.

26. Calculate the percentage composition of cane sugar and of glucose.

27. Calculate the percentage of water of hydration in crystalline cupric sulphate.

28. What are the percentage compositions of substances possessing the following formulas:  $\text{Mn}_3\text{O}_4$ ,  $\text{NaCl}$ , and  $\text{SiF}_4$  ?

29. Calculate the percentage composition of propylene ( $\text{C}_3\text{H}_6$ ) and propane ( $\text{C}_3\text{H}_8$ ).

30. Find the per cent of carbon in (a)  $\text{CH}_4$ ; (b)  $\text{C}_2\text{H}_2$ ; (c)  $\text{C}_2\text{H}_4$ ; (d)  $\text{COS}$ ; (e)  $\text{C}_4\text{H}_{10}$ ; (f)  $\text{C}_6\text{H}_{10}\text{O}_5$ .

31. Calculate the percentage composition of the following compounds:

Water,

Potassium chlorate,

Mercuric oxide,

Calcium carbonate,

Silver chloride,

Magnesium pyrophosphate,

Potassium nitrate,	Potassium platinum chloride,
Sodium nitrate,	Sodium thiosulphate,
Barium sulphate,	Magnetic oxide of iron.

32. How much weight will 32.2 g. crystallized sodium sulphate lose on heating?

33. How many lb. of dry  $\text{Na}_2\text{CO}_3$  is contained in a lb. of crystallized washing soda?

34. How many lb. of plaster of Paris can be made by calcining 10 Kg. of gypsum?

35. What is the percentage of sodium in Glauber's salt?

36. How many g. of C and of S are contained in 1292 g. of  $\text{CS}_2$ ?

37. It is required to find the weight of iron in 1000 Kg. of ferric oxide.

38. How many g. of copper in 3 Kg. of Scheele's green ( $\text{CuHAsO}_3$ )?

39. What weight of Ca, P, and O are contained in 100 g. bone ash?

40. How much oxygen in 10 g. lime; 6 g. litharge; 4 g. nitric acid; 10 g. sand?

41. How many g. of sodium in  $\frac{1}{2}$  ton of  $\text{NaNO}_3$ ?

42. How many g. of mercury in 20 g. of (a) corrosive sublimate; (b) 26 g. calomel; (c) 13 g. mercuric sulphide?

43. How much sodium in (a) 10 g.  $\text{NaOH}$ ; (b) 6 g.  $\text{Na}_2\text{SO}_4$ ; (c) 14 g.  $\text{NaCl}$ ; (d) 2 g.  $\text{NaHSO}_4$ ?

44. Find the percentage composition of (a) galena; (b) zinc blende.

45. Find the percentage composition of  $\text{Cu}(\text{NO}_3)_2$ ;  $\text{Pb}(\text{NO}_3)_2$ .

46. It was found by experiment that 10 g. of crystallized sodium sulphate contained 4.70 g. of water; how many molecules of water of hydration does the crystallized salt contain?

47. What is the percentage of copper in crystallized copper sulphate?

48. What is the percentage of nitrogen in "caliche" that is 97.8 per cent pure?

49. A room 15 ft. long and 10 ft. wide and high is covered with a paper containing 0.78 g. of Scheele's green per ft.<sup>2</sup>. How much arsenic is there in the room?

50. How many g. of Pb is contained in each of the following: (a) 10 g. litharge; (b) 10 g. minium; (c) 10 g. lead peroxide?

51. Which is cheaper,  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10 \text{H}_2\text{O}$  at 7 cents a pound, or the anhydrous salt at 5 cents a pound?

52. How many Kg. of water will be set free when 1 ton of crystallized copper sulphate is converted into the anhydrous condition on heating?

53. How much copper in (a) 10 g.  $\text{Cu}_2\text{O}$ ; (b) 13 g. azurite [ $2 \text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$ ]; (c) 2 g.  $\text{CuS}$ ?

54. What is the weight of Ca in 3 g. of calcium sulphate?

55. One g. of soft coal on analysis gave 0.0593 g. of barium sulphate. What is the percentage of sulphur in the sample of coal?

56. How much arsenic is there in 3 g. of magnesium arsenite?

57. Five g. of galena gave on analysis 5 g. of lead sulphate. What is the percentage of lead?



58. How many pounds of red lead can be made from 500 lb. of litharge ?

59. How much anhydrous salt in a Kg. of crystalline (a) copper sulphate; (b) washing soda; (c) Epsom salts; (d) alum; (e) Glauber's salt ?

60. Find the g. of lead in (a) 21 g.  $\text{PbO}_2$ ; (b) 13 g.  $\text{PbSO}_4$ ; (c) 14 g. sugar of lead; (d) 91 g. cerussite ( $\text{PbCO}_3$ ).

61. How much (1) oxygen, (2) chlorine, can be obtained from 100 g. bleaching powder ?

62. How many pounds of phosphorus in 265 pounds of calcium phosphate ?

63. What weight of barium sulphate can be obtained from 10 g. of crystallized magnesium sulphate ?

64. Calculate the percentage composition of  $\text{Na}_2\text{S}_2\text{O}_3$ , 5  $\text{H}_2\text{O}$ ; find the number of g. of water in 17 g. of the salt.

65. Find the percentage of hydrogen in (a)  $\text{HCl}$ ; (b)  $\text{H}_2\text{S}$ ; (c)  $\text{NH}_3$ ; (d)  $\text{CH}_4$ ; (e)  $\text{HF}$ .

66.  $\text{KClO}_3$  is 39% oxygen; calculate the g. of oxygen in (a) 76 g.; (b) 276 g.; and (c) 700 g.

67. A sample of air consists of 12.37 g. N and 3.63 g. O. Find the percentage of each.

## CHAPTER IV

### Changes in Volume

- Due to (I) changes in pressure alone ;  
(II) changes in temperature alone ;  
(III) changes in both temperature and pressure.*

*I. Changes in volume due to difference in pressure.*

1. The pressure on 134 cc. of air is increased from 480 mm. to 1200 mm. Find the new volume.
2. The pressure of 240 cc. of nitrogen is increased from 720 mm. to 780 mm. Find the new volume.
3. The pressure of 25 l. HCl is decreased from 863 mm. to 621 mm. Find the new volume.
4. The pressure of 15 l. of oxygen is increased from 700 mm. to 800 mm. Find the new volume.
5. The pressure on 10 cc. of gas is 7 m.; if the pressure is reduced to 847 mm., what is the new volume?
6. The pressure of 1000 cc. of a gas is decreased from 774 mm. to 600 mm. Find the new volume.
7. The pressure of 512 cc. of hydrogen is increased from 744 mm. to 790.5 mm. Find the new volume.
8. The barometric pressure of 5000 cc. of hydrogen is increased from 740 mm. to 760 mm. Find the new volume.

9. Reduce the following volumes to the volume occupied at standard pressure: (a) 221 cc. at 963 mm.; (b) 30 cc. at 662 mm.; (c) 100 l. at 1461 mm.

10. Under standard conditions 1 l. of oxygen weighs 1.4336 g.; what is the pressure when 1 l. weighs 1.29 g.

11. Under a pressure of 745 mm. 1500 cc. of a gas weigh 1.9762 g.; what is the weight per l. under standard pressure?

12. A body of gas occupies 2000 cc. when the barometer stands at 750 mm. What volume, at the same temperature, will it occupy at 760 mm.?

13. I have  $4\frac{1}{2}$  l. oxygen under a pressure of 750 mm. At 730 mm., what space will it fill?

14. At 850 mm., what should be the volume of a gas which at 600 mm. fills 100 cc.?

15. What volume will the same gas occupy at 200 mm. pressure?

16. One l. of air at normal pressure and temperature weighs 1.293 g. Under what pressure will the same volume weigh 2 g.?

17. CO has a volume of 18 l. at a pressure of 500 mm. Find volume at 650 mm.

18. If 27 l. of gas at 690 mm. now occupy 31 l., what is the new pressure?

19. A balloon containing 1200 cm.<sup>3</sup> of coal gas under a pressure of 770 mm. ascends until the barometer stands at 530 mm. What volume would the gas in the balloon now occupy, supposing none to have escaped?

20. A certain volume of air preserved at a constant temperature measures 150 cc. when the barometer stands at 760 mm. On the following day its volume

is found to have decreased 1.52 cc. Calculate the alteration in the height of the barometer which must have ensued.

21. What will be the excess of pressure inside a bottle of soda water when four volumes of carbon dioxide are dissolved in one volume of water?

22. A volume of hydrogen measuring 195 cc. when the barometer stood at 740 mm. was afterward found to measure 200 cc. What was the height of the barometer at that time?

23. A flask having a capacity of 4.5 l. is filled with a gas when the barometer stands at 755 mm. What would be the volume of the same gas in cc. when the barometer stands at 762 mm.?

24. A volume of hydrogen in a bell jar over mercury measured 524 cc. The mercury in the jar was 54 mm. above the surface of the mercury in the trough, and the barometer stood at 745 mm. What would have been the volume if exposed to the standard pressure alone?

25. A volume of gas was found to be equal to 250 cc. when the height of the barometer was 742 mm. What would have been the volume had the barometer stood at 760 mm.?

26. A volume of gas measured 467 cc. when the barometer stood at 756 mm. What would it have measured had the barometer stood at 760 mm.?

27. A volume of air measured 137 cc. when the barometer stood at 766 mm. What would it have measured had the barometer stood at 757 mm.?

28. If a certain mass of gas occupies 800 cc. at a pressure of 76 cm., what would its volume be at 74 cm. pressure?

29. Into what space must 60 ft.<sup>3</sup> of air be compressed that its expansive force may be made twelve times as great?

30. How strong would a compression tank have to be if its capacity is 600 in.<sup>3</sup> and 5 ft.<sup>3</sup> of air at normal pressure is forced into it?

31. What will be the weight of a l. of air under a pressure of 300 in. of mercury?

32. A rectangular diving bell 14 ft. high is sunk to the bottom of a lake at a point where the water is 60 ft. deep. Find how high the water will rise in the bell.

## *II. Volume with temperature alone changing.*

33. If 170 volumes of oxygen are measured at + 10° C., what will the volume be when the temperature falls to 0° C.?

34. If 10 cc. of a gas are measured at + 15° C., what volume will the gas occupy at + 150° C.?

35. If 100 cc. of hydrogen are measured at + 200° C., how many cc. will the gas occupy at - 200° C.?

36. Calculate the temperature at which air possesses a density equal to that of hydrogen at 0° C.

37. A mass of gas at 0° C. measures 2000 cc. Find the volume at (a) - 7° C.; (b) + 10° C.; (c) + 27° C.; (d) + 106° C.; (e) - 23° C.

38. An open vessel was heated until one-third of the air it contained at 0° C. was driven out; how much was it heated?

39. How much must a l. of air at + 10° C. be heated in order to increase its volume two-thirds?

40. At what temperature would nitrogen have the same density that hydrogen has at  $0^{\circ}\text{C}.$ ?

41. What will be the volume of 250 cc. of hydrogen measured at  $+30^{\circ}\text{C}.$  when cooled to  $-10^{\circ}\text{C}.$ ?

42. What will be the volume at  $+25^{\circ}\text{C}.$  of 252 cc. of oxygen measured at  $+15^{\circ}\text{C}.$ ?

43. If 170 volumes of oxygen are measured at  $+10^{\circ}\text{C}.$ , what will the volume be if the temperature falls to  $0^{\circ}\text{C}.$ ?

44. When 600 cc. of oxygen at  $+21^{\circ}\text{C}.$  are cooled to  $-8^{\circ}\text{C}.$ , what is the new volume?

45. A certain weight of air measures a l. at  $0^{\circ}\text{C}.$ ; how much will the air expand on being heated to  $+100^{\circ}\text{C}.$ ?

46. What is the temperature when 15 l. of a gas at  $+20^{\circ}\text{C}.$  will occupy a volume of 18.6 l.?

47. A flask holding 600 cc. of air at  $0^{\circ}\text{C}.$  is heated to  $+25^{\circ}\text{C}.$ ; what volume of expanded air escapes? Temperature of escaped air is  $+25^{\circ}\text{C}.$  Neglect expansion of flask.

48. A volume of gas measuring 500 cc. at  $0^{\circ}\text{C}.$  was expanded by heating to 600 cc. at constant atmospheric pressure; what temperature did the gas attain?

49. A rubber balloon containing 400 cc. of oxygen measured at  $-20^{\circ}\text{C}.$  is subjected to a temperature of  $+120^{\circ}\text{C}.$  What is the increase in volume of the balloon?

50. At what temperature will 1 l. of chlorine weigh the same as 1 l. of hydrogen; 1 l. of  $\text{N}_2\text{O}$ ; 1 l. of  $\text{NH}_3$ ?

51. If 100 cc. of a gas at  $+10^{\circ}\text{C}.$  is found to change its volume to 110 cc., at what temperature is it then?

52. The temperature of a gas being raised from  $-15^{\circ}\text{C.}$  to  $+10^{\circ}\text{C.}$ , it now measures 200 cc. Find the original volume.

53. What volume will 1000 cc. of air at  $+13^{\circ}\text{C.}$  occupy at  $+65^{\circ}\text{C.}$ ?

54. If 300 cc. of gas are measured off at  $+28^{\circ}\text{C.}$ , what will the volume become at  $-14^{\circ}\text{C.}$ ?

55. A l. of gas is heated from  $+14^{\circ}\text{C.}$  to  $+42^{\circ}\text{C.}$  Find the new volume.

56. A l. of air at  $+39^{\circ}\text{C.}$  is cooled to  $-26^{\circ}\text{C.}$  Find the new volume.

57. What volume will 50 cc. of gas at  $+10^{\circ}\text{C.}$  occupy at  $+24^{\circ}\text{C.}$ ?

58. If 100 cc. of air at  $+12^{\circ}\text{C.}$  are heated until they occupy 145 cc., what is the new temperature?

59. A volume of air, measuring 230 cc., was standing in a l. flask over water, the temperature of which was  $+26^{\circ}\text{C.}$  The temperature was then raised to  $+60^{\circ}\text{C.}$  How much water then remained in the flask?

60. I have a l. flask full of hydrogen at  $+15^{\circ}\text{C.}$  I wish to expel half the gas. To what temperature must it be heated?

61. I have a l. flask full of oxygen standing over water at  $+90^{\circ}\text{C.}$  I wish 100 cc. of water to enter the flask. What must be the temperature?

62. 3 l. of chlorine and 5 l. of hydrogen were mixed and exposed to sunlight at a temperature of  $+15^{\circ}\text{C.}$  It was found, after the  $\text{HCl}$  had been formed, that the temperature had risen to  $+40^{\circ}\text{C.}$  What volume did the gases then occupy?

63. Below  $+500^{\circ}\text{C}$ . sulphur has six atoms to the molecule; above  $+500^{\circ}\text{C}$ . it has only two atoms to the molecule. We have 300 cc. of sulphur gas at  $+450^{\circ}\text{C}$ . What will be the volume at  $+800^{\circ}\text{C}$ .?

64. If 1000 cc. of gas are heated from  $0^{\circ}\text{C}$ . to  $+39^{\circ}\text{C}$ ., what is the new volume?

65. If 1000 cc. of gas are heated from  $+39^{\circ}\text{C}$ . to  $+52^{\circ}\text{C}$ ., what is the new volume?

66. What volume will 20 ft.<sup>3</sup> of air at  $-7^{\circ}\text{C}$ . have at  $+7^{\circ}\text{C}$ .?

67. If the vapor density of a gas is 32 at the temperature of  $+15^{\circ}\text{C}$ ., at what temperature will it have a vapor density of 28.16?

68. A quantity of gas was measured when its temperature was  $+12^{\circ}\text{C}$ . At what temperature would its volume be doubled?

69. An open vessel was heated to  $+819^{\circ}\text{C}$ . What portion of the air that the vessel contained at  $0^{\circ}\text{C}$ . remained in it?

70. An open vessel was heated till  $\frac{1}{3}$  of the gas that it contained at  $+15^{\circ}\text{C}$ . was driven out. What was the temperature of the vessel?

71. A volume of air measured 475 cc. at  $+27^{\circ}\text{C}$ . What would have been its volume at  $0^{\circ}\text{C}$ .?

72. A quantity of hydrogen measured 550 cc. at  $+15^{\circ}\text{C}$ . What would have been its volume had its temperature been  $-10^{\circ}\text{C}$ .?

73. A given weight of air measured 256 cc. at  $+34^{\circ}\text{C}$ . What would have been its volume had its temperature been  $0^{\circ}\text{C}$ .?



74. A volume of nitrogen measured 3.5 l. at  $+75^{\circ}\text{C}$ . What would have been its volume had its temperature been  $+15^{\circ}\text{C}$ .?
75. A volume of gas measured 50 cc. at  $+15^{\circ}\text{C}$ . At what temperature would its volume be 44 cc.?
76. What volume will 400 l. of illuminating gas at  $+60^{\circ}\text{C}$ . occupy at  $+22^{\circ}\text{C}$ ., if there is no change of pressure?
77. If 100 cc. of hydrogen are measured at  $+100^{\circ}\text{C}$ ., how many cc. will the gas occupy at  $-100^{\circ}\text{C}$ .?
78. What volume will 1000 cc. of hydrogen at  $0^{\circ}\text{C}$ . occupy at (a)  $+15^{\circ}\text{C}$ .; (b)  $+20^{\circ}\text{C}$ .; (c)  $+300^{\circ}\text{C}$ .?
79. A gas has its temperature raised from  $+19^{\circ}\text{C}$ . to  $+50^{\circ}\text{C}$ .; at the latter temperature it measures 15 l. What was the initial volume?
80. A certain weight of air measures a l. at  $0^{\circ}\text{C}$ . How much will the air expand on being heated to  $+100^{\circ}\text{C}$ .?
81. A volume of hydrogen measures 1500 cc. at  $0^{\circ}\text{C}$ . How many cc. will it measure at (a)  $+15.5^{\circ}\text{C}$ .; (b) at  $+50^{\circ}\text{C}$ .; (c) at  $+400^{\circ}\text{C}$ .; (d) at  $+600^{\circ}\text{C}$ .? At what temperature will it measure exactly 1000 cc.?
82. If 10 cc. of a gas are measured at  $+18^{\circ}\text{C}$ ., what volume will the gas occupy at  $+150^{\circ}\text{C}$ .?
83. Calculate the temperature at which air possesses a density equal to that of methane at  $0^{\circ}\text{C}$ .
84. If the sp. gr. of air at  $+20^{\circ}\text{C}$ . normal pressure is 0.00118, what will be the weight of a l. of air at  $-20^{\circ}\text{C}$ .?
85. A volume of air at  $0^{\circ}\text{C}$ . measures 1 l.; what will be its volume at  $+18^{\circ}\text{C}$ .?

86. A volume of air at  $+91^{\circ}\text{C}$ . measures 1000 cc. Reduce the volume to standard temperature.

87. An open vessel is heated from  $0^{\circ}\text{C}$ . to  $+546^{\circ}\text{C}$ . What portion of the air that it at first contained now remains?

88. Find the volume of the following at  $0^{\circ}\text{C}$ .: (a) 170 cc. at  $+13^{\circ}\text{C}$ .; (b) 400 cc. at  $+14^{\circ}\text{C}$ .; (c) 771 cc. at  $+1^{\circ}\text{C}$ .; (d) 288 cc. at  $-7^{\circ}\text{C}$ .; (e) 300 cc. at  $+200^{\circ}\text{C}$ .

89. A l. flask filled with air at  $-10^{\circ}\text{C}$ . is heated to  $+70^{\circ}\text{C}$ . What will be the volume of the air that escapes if measured at  $0^{\circ}\text{C}$ .?

### *III. Volume with pressure and temperature both changed.*

90. Given 800 cc. of nitrogen at  $-1^{\circ}\text{C}$ . and 721 mm., what will be the volume at  $+1^{\circ}\text{C}$ . and  $\frac{1}{2}$  an atmosphere pressure?

91. A certain quantity of nitrogen measures 155 cc. at  $+10^{\circ}\text{C}$ . and under a pressure of 530 mm. What will the volume become at  $+18.7^{\circ}\text{C}$ . and under a pressure of 590 mm.?

92. A volume of hydrogen at a temperature of  $+15^{\circ}\text{C}$ . measured 2.7 l. when the barometer stood at 752 mm. What would have been its volume had its temperature been  $+9^{\circ}\text{C}$ . and the barometer stood at 762 mm.?

93. Given 18 cc. gas at  $+16^{\circ}\text{C}$ . and 772 mm., what will be the volume at  $0^{\circ}\text{C}$ . and 760 mm.?

94. Given 14 cc. gas at  $+11^{\circ}\text{C}$ . and 900 mm., what will be the volume at  $+3^{\circ}\text{C}$ . and 790 mm.?

95. Given 2.7 l. at  $+18^{\circ}\text{C}$ . and 749 mm., what will be the volume at  $0^{\circ}\text{C}$ . and 760 mm.?

96. Given 500 cc. of a gas at  $+163^{\circ}\text{C}$ . and 8.72 mm., find its volume at  $+77^{\circ}\text{C}$ . and 10 mm. .

97. A volume of air at standard temperature and pressure is compressed to  $\frac{1}{6}$  its original volume, and the temperature is then raised to  $+25^{\circ}\text{C}$ . What will now be the pressure in atmospheres?

98. If 1500 cc. of nitrogen at  $+57^{\circ}\text{C}$ . and 780 mm. are cooled to  $+27^{\circ}\text{C}$ ., the pressure being decreased to 740 mm., what is the new volume?

99. Given 500 cc. of hydrogen at  $+25^{\circ}\text{C}$ . and 760 mm. pressure, what will be the volume at  $+115^{\circ}\text{C}$ . and 755 mm.?

100. I fill a flask of 2 l. capacity with hydrogen when the thermometer indicates  $+25^{\circ}\text{C}$ . and the barometer 762 mm. What is the volume at  $0^{\circ}\text{C}$ . and 760 mm.?

101. I measure a volume of nitrous oxide at 755 mm. and  $+17^{\circ}\text{C}$ ., and find 360 cc. What volume should it occupy at 960 mm. and  $+37^{\circ}\text{C}$ .?

102. Compute the volume of carbon dioxide at 300 mm. and  $+50^{\circ}\text{C}$ . which is 25 l. at  $+20^{\circ}\text{C}$ . and 700 mm.

103. A certain mass of gas measures 11,000 gal. at  $+14^{\circ}\text{C}$ . and 740 mm. pressure. To what volume will it expand when the temperature reaches  $+27^{\circ}\text{C}$ . and the pressure 620 mm.?

104. If 100 l. of gas at  $+30^{\circ}\text{C}$ . and 731 mm. is cooled to  $+25^{\circ}\text{C}$ . while the pressure rises to 790 mm., and is then measured again, what is its new volume?

105. Given 500 l. of ammonia gas at  $+135^{\circ}\text{C}$ . and 752 mm., what will be its volume at  $+100^{\circ}\text{C}$ . and 760 mm.?

**106.** Given 730 cc. of nitrogen at  $+25^{\circ}\text{C}$ . and 770 mm., what will be the volume of this mass of gas at  $-30^{\circ}\text{C}$ . and 710 mm.?

**107.** A quantity of illuminating gas measures 5 l. and 25 cc. at  $+17^{\circ}\text{C}$ . and 760 mm. What will be its volume at  $+100^{\circ}\text{C}$ . and 735 mm.?

**108.** If 175 cc. of gas are measured at  $+20^{\circ}\text{C}$ . and 785 mm., what would be the volume of the same mass of gas at  $0^{\circ}\text{C}$ . and 760 mm.?

**109.** Given 125 cc. of gas at  $+1^{\circ}\text{C}$ . and 750 mm., what will be the volume at  $0^{\circ}\text{C}$ . and 650 mm.?

**110.** Given 40 pt. of gas at  $+10^{\circ}\text{C}$ . and 740 mm., what is the volume at  $-10^{\circ}\text{C}$ . and 630 mm.?

**111.** Given 1 ft.<sup>3</sup> of gas at  $-110^{\circ}\text{C}$ . and 510 mm., what is the volume at  $+25^{\circ}\text{C}$ . and 820 mm.?

**112.** Given 1 gal. of gas at  $+21^{\circ}\text{C}$ . and 722 mm., what is the volume at  $0^{\circ}\text{C}$ . and 760 mm.?

**113.** Given 300 l. of gas at  $-100^{\circ}\text{C}$ . and 310 mm., what is the volume at  $0^{\circ}\text{C}$ . and 760 mm.?

**114.** Given 22.16 m.<sup>3</sup> of gas at  $0^{\circ}\text{C}$ . and 760 mm., what is the volume at  $+25^{\circ}\text{C}$ . and 750 mm.?

**115.** Given 0.18 l. of gas at  $0^{\circ}\text{C}$ . and 760 mm., what is the volume at  $-25^{\circ}\text{C}$ . and 770 mm.?

**116.** If a room measures 10 m. by 100 dm. by 1000 cm., what volume of air will escape from it if the temperature changes from  $-11^{\circ}\text{C}$ . to  $-15^{\circ}\text{C}$ .? What volume if the pressure changes from 760 mm. to 735 mm.? What volume if both temperature and pressure change together?

**117.** What mass of oxygen at  $+10^{\circ}\text{C}$ . and 750 mm. would fill a globe of 16 l. capacity?

**118.** If the volume of a mass of ammonia is 500 cc. at  $+40^{\circ}\text{C}$ . and under the pressure of 60 mm., what would it be under the pressure of 35 mm. at  $+20^{\circ}\text{C}$ .?

**119.** If the volume of a mass of nitrogen is 50 cc. at  $+20^{\circ}\text{C}$ . and under the pressure of 60 cm., what would it be under the pressure of 900 mm. at  $+100^{\circ}\text{C}$ .?

**120.** If the volume of a mass of carbon dioxide is 2050 cc. at  $+200^{\circ}\text{C}$ . and under the pressure of 5 cm., what would be the volume in l. under the pressure of 400 mm. at  $+50^{\circ}\text{C}$ .?

**121.** If the volume of a mass of steam is 50,000 cc. at  $200^{\circ}\text{C}$ . and under the pressure of 1200 cm., what would be the volume in l. under the pressure of 20,000 mm. at  $+250^{\circ}\text{C}$ .?

**122.** If 470 cc. of nitrous oxide at  $+40^{\circ}\text{C}$ . stand in a tube over mercury, the level within the tube being 70 mm. above that without, and the barometric pressure being 740 mm., what would be the volume of the gas at  $+15^{\circ}\text{C}$ ., the barometric pressure being 765 mm. and the level within the tube being 20 mm. below that without?

**123.** If 1 l. of carbon dioxide at  $+18^{\circ}\text{C}$ . stand in a tube over mercury, the level within the tube being 125 mm. below that without, and the barometric pressure being 755 mm., what would be the volume of the gas at  $+50^{\circ}\text{C}$ ., the barometric pressure being 74 cm. and the level within the tube being 500 mm. above that without?

**124.** If 300 cc. of air at  $+20^{\circ}\text{C}$ . stand in a tube over mercury, the level within the tube being 20 cm. above that without, and the barometric pressure being 750 mm., what would be the volume of the gas at

+ 100° C., the barometric pressure being 760 mm. and the level within the tube being 70 cm. above that without?

**125.** If the pressure of 300 cc. of gas is 600 mm. at + 5° C., what pressure would be required to maintain the volume at 350 cc. at + 100° C.?

**126.** What volume will 30 g. of oxygen occupy at + 200° C. under the pressure of 80 cm. of mercury?

**127.** At what temperature will  $\frac{1}{2}$  Kg. of sulphur dioxide have a volume of 40 l. under 5 atmospheres pressure?

**128.** How many g. of nitrous oxide will occupy 900 cc. under the pressure of 2 atmospheres at + 50° C.?

**129.** If 320 cc. of gas are measured at + 91° C. and 950 mm., what is the normal volume?

**130.** If 542 cc. of air at + 269° C. and 900 mm. are cooled to + 51° C., the pressure being decreased to 666 mm., what is the new volume?

**131.** If 546 cc. of gas at + 17° C. and 760 mm. are cooled to 0° C., the pressure being decreased to 600 mm., what is the new volume?

**132.** A quantity of oxygen which measures 230 l. at + 14° C. and 740 mm. will measure how much at 0° C. and 760 mm.?

**133.** If 1234 cc. of normal gas are cooled to - 52° C., the pressure being decreased to 617 mm., what is the new volume?

**134.** The volume of a gas contained in a tube measures 86 cc., the mercury standing at a height of 34 mm. in the tube. Barometric pressure is 742 mm.; temperature is + 23° C. What is the normal volume of the gas?

**135.** One l. of oxygen at  $0^{\circ}\text{C}$ . and 760 mm. pressure weighs 1.4296 g. What will it weigh at the same temperature with the barometer standing at 780 mm.?

**136.** What will be the weight of 300 cc. of oxygen at  $+18^{\circ}\text{C}$ . and with the barometer at 730 mm.?

**137.** Under standard pressure at what temperature will 1 l. of oxygen weigh 1 g.?

**138.** What will be the volume of 200 g. of oxygen at 770 mm. pressure and  $+27^{\circ}\text{C}$ .?

**139.** A volume of hydrogen measuring 500 cc. at  $+25^{\circ}\text{C}$ . and 730 mm. was reduced in volume to 400 cc. at  $0^{\circ}\text{C}$ . What was the final pressure of the gas?

**140.** If 150 cc. of air are measured over water at  $+18^{\circ}\text{C}$ . and 746 mm. pressure, what will be the volume at standard conditions?

**141.** Since 1 l. of oxygen at standard conditions weighs 1.429 g., 440 cc. of this gas measured over water at  $+24^{\circ}\text{C}$ . and 742 mm. pressure will contain what weight of the dry gas?

**142.** What increase in pressure is necessary to force 100 cc. of hydrogen at  $+46^{\circ}\text{C}$ . and 740 mm. into a vessel of 80 cc. capacity, when the temperature of this vessel is constant at  $0^{\circ}\text{C}$ .?

**143.** Find volume under standard conditions of a mass of oxygen occupying 75 cc. at  $+40^{\circ}\text{C}$ . and 750 mm. pressure.

**144.** Chlorine occupies 20 l. at 720 mm. and  $+20^{\circ}\text{C}$ . Find volume when conditions change to 790 mm. and  $+30^{\circ}\text{C}$ .

**145.** A flask of air at standard conditions weighs 26 g. What capacity must it be, when filled with oxygen at  $+14^{\circ}\text{C}$ . and 753 mm., to weigh 26.73 g.?

**146.** The conditions in a vessel are  $+11^{\circ}\text{C}$ . and 800 mm. What expansion would there be if the temperature changed to  $+100^{\circ}\text{C}$ . and the pressure to 766 mm.?

**147.** A cylinder contains air at  $+5^{\circ}\text{C}$ . and 4 atmospheres pressure. Show that if the air is heated to  $+565^{\circ}\text{C}$ . the cylinder must be able to stand a pressure of over 12 atmospheres in order not to break.

**148.** A l. of air is measured at  $0^{\circ}\text{C}$ . and 760 mm. What volume will it occupy at 740 mm. and  $+15.5^{\circ}\text{C}$ .?

**149.** Given 375 cc. of oxygen at  $+17^{\circ}\text{C}$ . and 375 mm., what will be the volume at standard conditions?

**150.** Given 3 l. hydrogen at  $+15^{\circ}\text{C}$ . and 752 mm., what will be the volume at  $+9^{\circ}\text{C}$ . and 763 mm.?

**151.** What is the sp. gr. of oxygen when the barometer stands at 760 mm. and its temperature is  $0^{\circ}\text{C}$ ., if its sp. gr. is 14.7648 when the barometer stands at 745 mm. and its temperature is  $+17^{\circ}\text{C}$ .?

**152.** What decrease in pressure will be necessary to raise a volume of gas measuring over water 400 cc., at  $+22.5^{\circ}\text{C}$ . and 748 mm. pressure, to a volume of 440 cc. under the same conditions?

**153.** What increase in atmospheric pressure will be necessary to reduce 200 cc. of a gas, measured in a tube over water at  $+10^{\circ}\text{C}$ . and 720 mm., to a volume of 100 cc. at  $+20^{\circ}\text{C}$ . in this same tube?



154. If 98 l. of hydrogen are to be admitted into a balloon at a temperature of  $+20^{\circ}\text{C}$ . and a pressure of 740 mm., what must be the capacity of the balloon?

155. Of what capacity is that vessel which contains 4 Kg. of oxygen at the temperature of  $+18^{\circ}\text{C}$ . and a pressure of 748.4 mm.?

156. If 110.08 Hl. of hydrogen at  $0^{\circ}\text{C}$ . and 760 mm. pressure are to be forced into a vessel of 11.2 l. capacity, under what pressure will the hydrogen be at this same temperature?

157. What volume will 0.8 g. of hydrogen occupy at  $+100^{\circ}\text{C}$ . under the pressure of 750 mm. of mercury?

158. What pressure will be exerted by 10 g. of carbon monoxide, the volume of which is 15 l. at  $+20^{\circ}\text{C}$ .? (1 l. = 1.251 g.)

159. At what temperature will 20 g. of nitrous oxide fill a space of 8000 cc. under twice the atmospheric pressure? (1 l. = 1.969 g.)

160. What is the weight of 5 l. of oxygen under the pressure of 800 mm. of mercury at  $+40^{\circ}\text{C}$ .?

161. What will be the pressure of 10 g. of marsh gas, the volume of which is 15 l. at  $+30^{\circ}\text{C}$ .? (1 l. = 0.716 g.)

162. If a certain volume of gas weighs 5 g. at  $+50^{\circ}\text{C}$ . and 300 mm., what should a like volume of the same gas weigh if measured at  $+35^{\circ}\text{C}$ . and 500 mm.?

163. A volume of chlorine measured at  $+18^{\circ}\text{C}$ . and 756 mm. weighs 3 g. If the same volume had been found at  $+36^{\circ}\text{C}$ . and 700 mm., what would it have weighed? (1 l. Cl = 3.167 g.)

**164.** Carbon dioxide at N.T.P. weighs 1.98 g. per l. What would a l. of it weigh at  $+30^{\circ}$  C. and 800 mm.?

**165.** What is the volume of 20 g. of ammonia at  $+12^{\circ}$  C. and 730 mm.? (1 l. = 0.76 g.)

**166.** If 146 l. of nitrogen at  $+17^{\circ}$  C. and 974 mm. are heated to  $+51^{\circ}$  C., the pressure being decreased to 760 mm., what is the new volume?

**167.** What is the mass of 270 cc. of nitrogen measured over water at  $+8^{\circ}$  C. and 768 mm.? (1 l. = 1.25 g.)

**168.** A gas measured over water has a volume of 64.2 cc. at  $+18.6^{\circ}$  C. and 742.5 mm. Find what the volume would be at  $0^{\circ}$  C. and 760 mm.

**169.** Given 400 cc. of oxygen at standard conditions, what will be the volume when measured over water at  $+20^{\circ}$  C. and 755 mm. pressure?

**170.** Given 100 cc. of a gas measured over water at  $+25^{\circ}$  C. and 745 mm. pressure, what will be the volume when deprived of moisture?

**171.** Given 1000 cc. of oxygen measured over water at  $+10^{\circ}$  C. and 750 mm. pressure, what will be the volume at  $-10^{\circ}$  C. and 770 mm. pressure when deprived of moisture?

**172.** Given 500 cc. of a gas contained in a tube inverted over water, and measured at  $+10^{\circ}$  C. and 765 mm. pressure, what will be the volume under a change in the atmospheric conditions to  $+20^{\circ}$  C. and 745 mm. pressure?

**173.** A vessel of 2000 cc. capacity held 5 g. of a vapor at the standard conditions of temperature and pressure. What weight of this vapor at  $+10^{\circ}$  C. and

750 mm. pressure can be held in this vessel, the capacity considered constant?

**174.** Reduce the following to standard conditions: (a) 150 cc. at 603 mm. and  $+31^{\circ}\text{C}$ ; (b) 400 cc. at 876 mm. and  $-9^{\circ}\text{C}$ ; (c) 500 cc. at 371 mm. and  $+62.17^{\circ}\text{C}$ ; (d) 20 cc. at 700 mm. and  $-14^{\circ}\text{C}$ ; (e) 7 l. at 1376 mm. and  $+13^{\circ}\text{C}$ .

**175.** A certain volume of gas is enclosed in a vessel at 76 cm. pressure and  $-20^{\circ}\text{C}$ . It is then heated to  $+40^{\circ}\text{C}$ . What is the pressure on the sides of the vessel measured in terms of the atmosphere?

**176.** If 1000 cc. of chlorine at  $+46^{\circ}\text{C}$ . are in a tube over mercury which stands in the tube 39 mm. above that without, the pressure outside being 750 mm., what would be the volume of the gas under standard conditions?

**177.** The air in a flexible rubber bag is found to occupy a volume of 1 ft.<sup>3</sup> at 30 in. pressure and  $+20^{\circ}\text{C}$ . If the bag is plunged to a depth of 170 ft. in water, the temperature of which is  $+10^{\circ}\text{C}$ ., what will be its volume?

**178.** A vessel full of air at  $0^{\circ}\text{C}$ . is heated to  $+80^{\circ}\text{C}$ ., when 2 cc. of the air measured at  $0^{\circ}\text{C}$ . are found to have escaped. How much air was in the vessel before heating?

**179.** A l. of chlorine at  $0^{\circ}\text{C}$ . and 76 cm. pressure weighs 3.167 g. If the pressure is decreased to 74 cm., what must the temperature be that a l. of gas may weigh 2 g.?

**180.** If a l. of nitrogen at  $0^{\circ}\text{C}$ . and 76 cm. pressure weighs 1.25 g., how many l. at  $+25^{\circ}\text{C}$ . and 74 cm. pressure will be required to weigh 8 g.?

**181.** Find the volume of 4450 cc. of carbon dioxide, measured at standard conditions, at 890 mm. pressure and  $+27^{\circ}\text{C}$ .

**182.** A l. of hydrogen at 760 mm. pressure and  $0^{\circ}\text{C}$ . weighs 0.0899 g. What will 10 l. weigh at  $-20^{\circ}\text{C}$ . and 750 mm. pressure?

**183.** At what temperature, when under a pressure of 75 cm., will 2 l. of gas measured at  $+46^{\circ}\text{C}$ . and 76 cm. pressure measure 1.8 l.?

**184.** A gas at  $0^{\circ}\text{C}$ . and 760 mm. pressure measured 250 cc. What will it measure at  $-10^{\circ}\text{C}$ . and 760 mm. pressure?

**185.** A volume of gas in a eudiometer measures 242 cc. The mercury in the tube stands 18 cm. above that outside. Barometer at 740 mm.; temperature,  $+18^{\circ}\text{C}$ . Reduce to standard volume.

**186.** A volume of gas in a tube measures 72 cc. The mercury in the tube stands at the same level as that on the outside. Barometer 737 mm.; temperature  $+17^{\circ}\text{C}$ . What would be the volume under standard conditions?

**187.** The volume of gas in a eudiometer measures 68 cc., the level of the mercury in the tube and trough being the same. The barometer indicates an atmospheric pressure of 739 mm. The temperature is  $+20^{\circ}\text{C}$ . What would be the volume of the gas at  $0^{\circ}\text{C}$ . and under 760 mm. pressure?

**188.** The volume of gas contained in a tube measures 76 cc. The mercury in the tube stands at a height of 17 mm. Barometer indicates a pressure of 752 mm. The temperature is  $+9^{\circ}\text{C}$ . Find volume at  $0^{\circ}\text{C}$ . and 760 mm.

**189.** If the volume of a mass of gas is 500 cc. at  $+30^{\circ}\text{C}$ . and under the pressure of 100 mm., what would

it be under the standard conditions of atmospheric pressure and the temperature  $0^{\circ}\text{C}.$ ?

**190.** If the volume of a mass of hydrogen is 1000 cc. at  $+100^{\circ}\text{C}.$  and under the pressure of 800 mm., what would it be under standard conditions?

**191.** If the volume of a mass of oxygen is 400 cc. at  $+50^{\circ}\text{C}.$  and under the pressure of 600 mm., what would it be under standard conditions?

**192.** If the volume of a mass of air is 4 l. at  $+70^{\circ}\text{C}.$  and under the pressure of 80 cm., what would it be in cc. under standard conditions?

**193.** If 500 cc. of chlorine at  $+60^{\circ}\text{C}.$  stand in a eudiometer over mercury, the level within the tube being 90 mm. above that without and the barometric pressure being 750 mm., what would be the volume of the gas under standard conditions?

**194.** If 1250 cc. of nitrogen at  $+37^{\circ}\text{C}.$  stand in a eudiometer over mercury, the level within the tube being 20 mm. *below* that without and the barometric pressure being 747 mm., what would be the volume of the gas under standard conditions?

**195.** If 780 cc. of air at  $+28^{\circ}\text{C}.$  stand in a eudiometer over mercury, the level within the tube being 40 mm. above that without and the barometric pressure being 750 mm., what would be the volume of the gas under standard conditions?

**196.** If  $\frac{1}{2}$  l. of hydrogen at  $+70^{\circ}\text{C}.$  stands in a eudiometer over mercury, the level within the tube being 50 mm. below that without and the barometric pressure being 745 mm., what would be the volume of the gas in cc. under standard conditions?

**197.** If the temperature of a certain volume of air is increased from  $-10^{\circ}\text{C.}$  to  $+30^{\circ}\text{C.}$ , how much must the pressure be increased to keep the volume constant?

**198.** The barometer at  $0^{\circ}\text{C.}$  stands at 750 mm. At what height will it stand if the temperature rises to  $+39^{\circ}\text{C.}$ , the pressure remaining the same?

**199.** If a quantity of gas, measured at  $0^{\circ}\text{C.}$  and 75 cm. pressure, is subjected to a pressure of 775 mm., how much must the temperature be increased that the volume may remain the same?

**200.** A sample of moist air, confined over water at  $+15^{\circ}\text{C.}$  and 760 mm., occupies 15 cc. It is mixed with 20 cc. of hydrogen, the mixture is exploded, and suffers a contraction of 9.5 cc. What would be the volume of the oxygen it contained if measured dry at  $0^{\circ}\text{C.}$  and 760 mm.?

**201.** To how many atmospheres pressure must a l. of gas measured at 76 cm. pressure and  $-20^{\circ}\text{C.}$  be subjected to be condensed to  $\frac{1}{2}$  a l. when the temperature is  $+40^{\circ}\text{C.}$ ?

**202.** A volume of gas which measures 2 l. at 742 mm. was afterwards found to measure 2163 cc. What was the height of the barometer at the time of the second reading?

**203.** Some hydrogen under 900 mm. pressure and  $+20^{\circ}\text{C.}$  occupies 300 cc. What volume will it occupy at  $+109^{\circ}\text{C.}$  under 600 mm. pressure?

**204.** Find the pressure on the gas in a tube when the mercury inside and outside the tube are the same, and the temperature is  $+25^{\circ}\text{C.}$  and the barometer stands at 760 mm.

**205.** A 1. flask was filled with air at  $-10^{\circ}\text{C}$ . and 750 mm. pressure. If the barometer rises to 760 mm., to what temperature must the flask be raised to drive out  $\frac{1}{2}$  the air that was in it when it was filled?

**206.** The gas enclosed in a piston tube is compressed to  $\frac{1}{2}$  its original volume measured at 76 cm. pressure, and the temperature is raised from  $+10^{\circ}\text{C}$ . to  $+130^{\circ}\text{C}$ . What is the pressure on each cm.<sup>2</sup> of the piston?

**207.** When 1000 cc. of a gas were measured at  $+16^{\circ}\text{C}$ . and 750 mm., and the volume was increased to 1120 cc. by warming, the final pressure read 740 mm. What was the final temperature of the gas?

**208.** What decrease in temperature will be necessary to reduce 400 cc. of a gas at  $+20^{\circ}\text{C}$ . and 765 mm. to a volume of 300 cc. at 750 mm.?

**209.** If 1 g. of gunpowder yields, on explosion at  $0^{\circ}\text{C}$ . and 760 mm., 288 cc. of gases, what volume would be occupied at  $+2200^{\circ}\text{C}$ ., which is reached at the moment of exploding?

**210.** What change in temperature will be necessary to bring a volume of gas, measuring 5600 cc. at  $+10^{\circ}\text{C}$ . and 745 mm. pressure, to a volume of 600 cc. at this same pressure?

## CHAPTER V

### Volumes of Gases from Weights—Specific Gravity and Vapor Density

1. Calculate the density, weight of 1 l., and sp. gr. of the following gases:

$C_2H_2$ ,	CO,	$C_2H_4$ ,	$CH_4$ ,	$C_3H_8$ ,
$NH_3$ ,	COS,	HBr,	NO,	$C_3H_6$ ,
$AsH_3$ ,	$COCl_2$ ,	HCl,	$N_2$ ,	$SO_2$ ,
$Br_2$ ,	$Cl_2$ ,	HF,	$N_2O$ ,	$H_2O$ .
$C_4H_{10}$ ,	$C_2N_2$ ,	HI,	$O_2$ ,	
$CO_2$ ,	$C_2H_6$ ,	$H_2S$ ,	$PH_3$ ,	

2. Find the weight of 10 l. of NO. What volume will 5 g. of the gas occupy?

3. Find the weight of the following volumes of dry air at standard conditions: (a) 20 cc.; (b) 300 cc.; (c) 73 l.; (d) 30 mm.<sup>3</sup>.

4. Determine the weight, at 0° C. and 760 mm., of 1 l. of each of the following gases, on the assumption that they can exist in the gaseous condition at the standard temperature and pressure:

Water,	Trihydrogen phosphide,
Hydrogen chloride,	Alcohol,
Ammonium chloride,	Nitrogen monoxide,
Carbon dioxide,	Nitrogen tetroxide,
Carbon disulphide,	Mercuric chloride.



5. What is the weight of 1500 cc. of a gas at the standard pressure of 760 mm. and temperature of zero, if its sp. gr. referred to hydrogen is 14?

6. Under a pressure of 745 mm., 1500 cc. of chlorine weigh 4.67 g. What is the weight of 1 l. under standard pressure?

7. The formula for ethane is  $C_2H_6$ . Calculate the sp. gr. of its vapor (a) compared with hydrogen; (b) compared with air.

8. Two l. of hydrogen sulphide weigh 3.0442 g.; what is its sp. gr. referred to air?

9. The molecular weight of bromine is 160; what is the sp. gr.?

10. What will be the volume of phosphorus vapor obtained from 3 g. of solid phosphorus at  $+420^\circ C.$ ?

11. The density of carbon monoxide is 14; what is the weight of 1 l.?

12. How many l. of hydrogen in 2.7 g.?

13. How many l. of chlorine in 7.3 g.? How many cc.?

14. What volume of HCl in 50 g.?

15. If 2 l. of chlorine weigh 6.3 g., find the density of chlorine.

16. If 5 l. of  $CO_2$  weigh 9.9 g., what is its density?

17. If 3 l. of mercury vapor weigh 26.9 g., compute the vapor density of mercury.

18. Calculate the weight of 1 l. of each of the following gases: (a) chlorine; (b) nitrogen; (c) sulphur dioxide; (d) nitrous oxide; (e) nitric oxide; (f) ethane; (g) butane; (h) hydrogen chloride; (i) carbon monoxide; (j) carbon dioxide; (k) marsh gas; (l) phosphine.

19. What do 100 l. of nitrogen weigh?
20. Nitric oxide is 15 times as heavy as hydrogen; how many times is it heavier than air?
21. Calculate the density (referred to air) of propane.
22. Calculate the density (referred to air) of sulphur dioxide.
23. The vapor of silicon chloride is 5.936 times as heavy as air. Find its density compared with hydrogen.
24. A vessel holding 30.8 g. of carbon dioxide at  $+10^{\circ}\text{C}$ . and 740 mm. pressure is to be brought to a temperature of  $+50^{\circ}\text{C}$ . and a pressure of 750 mm. What weight and volume of carbon dioxide will be lost?
25. What is the weight of 6.594 l. of oxygen at  $+40^{\circ}\text{C}$ . and 740 mm. pressure?
26. The relative density of carbon dioxide is 21.83; what is the relative density of this gas upon the oxygen standard?
27. Find the density (air = 1) of the following: carbon monoxide; carbon disulphide; sulphur dioxide; boron trifluoride; phosphorus pentafluoride.
28. Find the volume at standard conditions of 1 g. H; 16 g. O; 14 g. N; 35.5 g. Cl; 80 g. Br vapor; 9 g. steam; 18.25 g. HCl; 22 g.  $\text{CO}_2$ ; 8 g.  $\text{CH}_4$ ; 32 g.  $\text{SO}_2$ ; 14 g. CO.
29. What weight of arsenic is contained in a l. of cacodyl oxide vapor,  $[(\text{CH}_3)_2\text{As}]_2\text{O}$ , measured at  $+500^{\circ}\text{C}$ .?
30. What is the volume of 3.0571 g. of a gas, if its sp. gr. referred to air is 0.591?

31. A hall is of such dimensions that it contains 507.0912 Kg. of air at  $0^{\circ}\text{C}$ . and 760 mm. What is the capacity of the hall measured in  $\text{m}^3$ ?

32. Determine the mass of 750 cc. of nitrogen measured over water at  $+20^{\circ}\text{C}$ . and 780 mm.

33. If 545 cc. of nitrogen are measured over water at  $+22^{\circ}\text{C}$ . and 748 mm. pressure, what weight will they contain of the dry gas?

34. What volume will 2.2 g. of oxygen at  $+20^{\circ}\text{C}$ . and 770 mm. pressure occupy when transferred to a vessel inverted over water?

35. What volume will 1 g. of hydrogen measured at standard conditions occupy when transferred to a vessel over water at  $0^{\circ}\text{C}$ . and 760 mm. pressure?

36. What volume will 310 g. of carbon dioxide occupy when contained in a vessel over water at  $+20^{\circ}\text{C}$ . and 742.4 mm. pressure?

37. What volume will 1 g. of oxygen occupy over water at  $+30^{\circ}\text{C}$ . and 756.5 mm. pressure?

38. At what temperature will 8 g. of oxygen under a pressure of 760 mm. occupy a volume of 11.1 l. at this same pressure?

39. Find the mass of 250 l. of chlorine at  $-7^{\circ}\text{C}$ . and 886 mm.

40. The sp. gr. of oxygen under standard conditions is 1.1; what is the sp. gr. when the barometer stands at 745 mm.?

41. The sp. gr. of oxygen referred to hydrogen is 16 at  $0^{\circ}\text{C}$ .; what is its sp. gr. when its temperature is  $+27^{\circ}\text{C}$ .?

42. If the sp. gr. of a gas is 22 at  $0^{\circ}\text{C}.$ , what will be its sp. gr. at  $+81.9^{\circ}\text{C}.$ ?

43. Calculate the weight of the following gases at standard pressure and temperature: 2 l. of hydrochloric acid gas; 1500 cc. of hydrogen sulphide; 250 cc. of chlorine; 5 l. of ethane ( $\text{C}_2\text{H}_6$ ).

44. The density of a substance referred to air is 3.2. What is the density referred to hydrogen? What will be the volume occupied by 10 g. of the substance at  $+20^{\circ}\text{C}.$  and 752 mm.?

45. How many g. do 10 l. of hydrogen phosphide weigh?

46. A l. of hydrogen under standard conditions weighs 0.09 g. What is the weight of a l. of ozone under the same conditions?

47. A gas has the formula  $\text{C}_3\text{H}_8$ . Is it lighter or heavier than air? Find the sp. gr.

48. Calculate the sp. gr. of cyanogen and the weight of 3 l.

49. Determine the mass of 7.3 l. marsh gas, 8 l. of ethylene, and 16 g. choke damp, measured at 760 mm. and  $0^{\circ}\text{C}.$

50. Find the weight at  $+182^{\circ}\text{C}.$  and 770 mm. occupied by 50 l. of (a) HF, (b) HI, (c) HCl.

51. What mass of nitrogen will measure 1000 cc. at  $+15^{\circ}\text{C}.$  and 765 mm.?

52. Find under standard conditions the weight of 1 l. of  $\text{CO}$ ,  $\text{CO}_2$ , and  $\text{CH}_4$ .

53. Find the mass of 5.6 l. of  $\text{CO}$ .

54. What space will 125 g. of iodine vapor occupy at  $+1900^{\circ}\text{C}.$  and 794 mm.?

55. What is the volume of 20 g. of carbon dioxide at the standard temperature and pressure?

56. What is the volume of 82.88 g. of the vapor of ethyl ether at the temperature of  $+147^{\circ}\text{C}$ . and under a pressure of 740 mm.?

57. What weight of carbon does 1 l. of  $\text{CO}_2$  contain; 1 l. CO?

58. What is the weight of 5 l. of ethyl alcohol vapor having a temperature of  $+127^{\circ}\text{C}$ . and under a pressure of 750 mm.?

59. What is the volume of a Kg. of carbon monoxide at  $0^{\circ}\text{C}$ . and 760 mm.?

60. What is the volume of 225 g. of hydrogen sulphide at  $0^{\circ}\text{C}$ . and 760 mm.?

61. Calculate the volume, at the standard temperature and pressure, of a Kg. of the following gases: carbon monoxide; ethylene; hydrogen sulphide; oxysulphide of carbon; methyl hydride; bromine; water.

62. What volume will 49.63 g. of chlorine occupy at standard conditions?

63. What is the volume occupied by 8.8 g. of carbon dioxide at  $+12^{\circ}\text{C}$ . and 752 mm. pressure?

64. Find the volume of 10 g.  $\text{N}_2\text{O}$ ; 13 g. NO; 7 g.  $\text{N}_2\text{O}_3$ ; 6 g.  $\text{N}_2\text{O}_4$ .

65. What volume of hydrogen is contained in 6 cc. of  $\text{NH}_3$ ?

66. Find the weight of 500 cc. of H; 250 cc. of Cl; 700 cc. of  $\text{CH}_4$ ; 130 cc. of  $\text{PH}_3$ .

67. Find the volume at  $+41^{\circ}\text{C}$ . and 785 mm. occupied by (a) 66 g.  $\text{CO}_2$ ; (b) 96 g.  $\text{AsH}_3$ .

68. The weight of 1 l. of aqueous vapor at  $0^{\circ}$  C. and 760 mm. is 0.8045 g; what is its relative density?

69. Calculate the relative density of mercury vapor, 1 l. of which at standard conditions weighs 8.87 g.

70. A l. of  $\text{NH}_3$  weighs 0.762 g. at  $0^{\circ}$  C. and 760 mm. Find (a) its vapor density; (b) its sp. gr.

71. Find the volume at  $+41^{\circ}$  C. and 78.5 mm. occupied by (a) 66 g.  $\text{CO}_2$ ; (b) 96 g. stibine.

72. What is the weight of 573 cc. of air at  $+30^{\circ}$  C. and 769 mm.?

73. What is the weight of a  $\text{m}^3$  of hydrogen at the standard temperature and twice the standard pressure?

74. What weight of hydrogen and of bromine in 1 l.  $\text{HBr}$  at  $+60^{\circ}$  C. and 760 mm.?

75. How many times heavier than a l. of hydrogen is (a) one of air; (b) one of oxygen; (c) one of chlorine; (d) one of nitrogen?

76. Find the weight of 300 cc.  $\text{NH}_3$ .

77. How many g. in 3000 cc. of  $\text{H}_2\text{S}$ , measured at  $+16^{\circ}$  C. and 780 mm.?

78. Determine the mass of 34 l. of (a)  $\text{NH}_3$ ; (b)  $\text{SO}_2$ ; (c)  $\text{SiF}_4$ ; (d)  $\text{C}_2\text{H}_2$ .

79. Find the volume at  $+10^{\circ}$  C. and 761 mm. occupied by (a) 3 g.  $\text{H}_2\text{S}$ ; (b) 13 g.  $\text{PH}_3$ ; (c) 2 g.  $\text{SbH}_3$ .

80. The weight of 2.3 l. of oxygen at  $0^{\circ}$  C. and 760 mm. is 3.2885 g. Find the sp. gr. referred to air.

81. Three l. of marsh gas weigh 2.15 g. What is its sp. gr., hydrogen being the standard?

**82.** At 760 mm. pressure, what is the weight of 1 l. of acetylene at  $0^{\circ}\text{C}.$ ; of hydrogen sulphide at  $0^{\circ}\text{C}.$ ; of steam at  $+150^{\circ}\text{C}.$ ; of water at  $+4^{\circ}\text{C}.$ ; of sulphuric acid, sp. gr. 1.84; of sulphur at  $+500^{\circ}\text{C}.$ ; of bromine at  $+4^{\circ}\text{C}.$ ; of bromine at  $+400^{\circ}\text{C}.$ ; of iodine at  $+500^{\circ}\text{C}.$ ; of iodine at  $+1500^{\circ}\text{C}.$ ?

**83.** What volume is occupied by 177.5 g. of chlorine?

**84.** Find the number of l. occupied by 64 g. of sulphur dioxide; occupied by 32 g. of oxygen; occupied by 2 g. of hydrogen; occupied by 16 g. of methane.

## CHAPTER VI

### Weights from Equations

1. How much  $\text{KClO}_3$  must be decomposed to yield 20 g. of oxygen? What weight of  $\text{KCl}$  will be left?
2. How many g. of  $\text{CO}_2$  will be produced by burning 100 g. of carbon in oxygen?
3. How many g. of hydrogen will result from placing 46 g. of sodium on water?
4. How many g. of acetylene gas will be generated by 750 g. of pure calcium carbide?
5. How many lb. of water would be needed to slake 15 lb. of  $\text{CaO}$ ?
6. In the changing of 500 lb. of  $\text{Ca(OH)}_2$  in mortar to  $\text{CaCO}_3$ , how many lb. of water are produced and how many l. of  $\text{CO}_2$  are needed?
7. How much plaster of Paris results from heating 100 Kg. of gypsum?
8. How many lb. of  $\text{CaO}$  and how many m.<sup>3</sup> of  $\text{CO}_2$  would be formed by heating 5 tons of limestone?
9. From 30 tons of sodium nitrate, how much nitric acid (80 %  $\text{HNO}_3$ ) can be produced? How much sulphuric acid is necessary to make it?
10. How much  $\text{CO}$  will result on heating 70 g. of  $\text{H}_2\text{C}_2\text{O}_4$  with concentrated  $\text{H}_2\text{SO}_4$ ?



11. If 100 g.  $\text{H}_2\text{C}_2\text{O}_4$  are heated with  $\text{H}_2\text{SO}_4$  and the gases are passed through a solution of  $\text{NaOH}$ , what volume of  $\text{CO}$  and what weight of  $\text{Na}_2\text{CO}_3$  will result?

12. What weight of  $\text{HCl}$  can be made from 50 g. of  $\text{NaCl}$ ?

13. What weight of arsenic would be obtained by reducing 157 g. of arsenic trioxide with charcoal?

14. If a candle consists of 85 % of carbon and 15 % of hydrogen, what weights of carbon dioxide and water will be formed when 25 g. of the candle burn?

15. To what weight of nitrous acid do 100 g. of nitrous anhydride correspond?

16. How much nitrogen peroxide is obtainable from 200 g. of nitric acid?

17. What weight of copper nitrate is obtainable from 50 g. of nitric acid and copper?

18. How much nitrogen peroxide can be made from 100 g. of nitric oxide?

19. How much hydrocyanic acid is obtainable from 70 g. of potassium cyanide?

20. How much cyanogen is obtainable from 200 g. of mercuric cyanide?

21. What weight of carbon dioxide will 300 g. of calcium carbonate yield on treatment with an acid?

22. What weight of  $\text{NaOH}$  and  $\text{HCl}$  will be needed to produce 75 g. of  $\text{NaCl}$ ?

23. If 100 Kg. of "fool's gold" are heated (*a*) in a tube, (*b*) in the air, what are the weights of the substances produced in each case?

24. What weight of  $\text{Na}_2\text{CO}_3$  will result from heating 500 g. of sodium dicarbonate?

25. What weight of washing soda would be needed to furnish 125 g. of anhydrous  $\text{Na}_2\text{CO}_3$ ?

26. What weight of nitric acid will be produced by heating 75 g. of Chili saltpeter with an excess of concentrated sulphuric acid?

27. What weight of sulphuric acid and sodium nitrate should be taken in order to obtain 215 g. of nitric acid?

28. If 78 g. of copper nitrate is decomposed by concentrated sulphuric acid, what weight of nitric acid and what weight of copper sulphate will be formed?

29. If copper and nitric acid react, what weight of metallic copper should be taken, if one Kg. of copper nitrate is to be formed?

30. What weight of nitrogen tetroxide ( $\text{N}_2\text{O}_4$ ) will result when 3300 cc. of nitric oxide (NO) is brought into contact with an excess of oxygen?

31. What weight of  $\text{N}_2\text{O}$  will be formed by heating 50 g. of  $\text{NH}_4\text{NO}_3$ ? How many g. of water will be formed?

32. What weight of  $\text{NH}_4\text{NO}_3$  will be taken to yield upon heating 1 l. of  $\text{N}_2\text{O}$ ?

33. What weight of  $\text{NH}_3$  will result upon decomposing 50 g. of  $\text{NH}_4\text{Cl}$  with slaked lime?

34. What weight of potassium and what weight of chlorine are contained in 17 g. of potassium chlorate?

35. How much potassium chloride would be formed by heating 35 g. of potassium chlorate?

36. How much  $\text{BaO}_2$  must be heated in order to obtain 14 g. of oxygen?

37. If potassium chlorate costs 80 cts. per Kg., what will be the cost of enough to make 500 g. of oxygen?

38. What weight of sodium will be necessary to decompose 15 g. of water? What weight of hydrogen will be formed?

39. What weight of sodium would be needed to produce, by the decomposition of water, 1 l. of hydrogen?

40. What weight of oxygen can be obtained by heating 18 g. of mercuric oxide?

41. How much mercuric oxide must be heated in order to obtain 2 g. of oxygen?

42. With what weight of mercury will 9 g. of oxygen unite to form mercuric oxide?

43. To obtain 15 g. of iodine, how much manganese dioxide, potassium iodide, and sulphuric acid will be required?

44. What weight of hydrofluoric acid would be evolved by treating 36 g. of calcium fluoride with sulphuric acid?

45. How much common salt will be needed to yield 10 g. of chlorine on treatment with manganese dioxide and sulphuric acid?

46. What weight of zinc sulphate will be formed upon treating 13 g. of zinc with sulphuric acid?

47. How much manganese dioxide will be required to liberate 13 g. of chlorine from hydrochloric acid?

48. What weight of chlorine will result from the electrolysis of a solution containing 65 g. of potassium chloride?

49. An ore contains 62.38% of arsenopyrite ( $\text{FeAsS}$ ). What weight of white arsenic could be obtained by heating 500 lb. of the ore?

50. What weights of mercury and sulphur dioxide could be obtained from 1 ton of an ore carrying 53.78% of cinnabar?

51. What weight of aluminum oxide is contained in 100 lb. of potassium alum?

52. What weight of aluminum hydroxide will be produced when a solution containing 35 g. of potassium alum is precipitated with ammonium hydroxide?

53. An ore contains 23.46 % of stibnite,  $\text{Sb}_2\text{S}_3$ ; what is the % of antimony in the ore?

54. How many lb. of calcium carbide will be necessary to produce 1300 g. of acetylene?

55. How many lb. of zinc may be obtained from a ton of an ore containing 17.3 % of zinc carbonate?

56. What weight of silicon tetrafluoride could be obtained by treating 430 g. of silica with hydrofluoric acid?

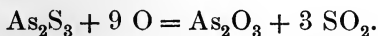
57. If 275 g. of silica is fused with an excess of potassium carbonate, what weight of potassium silicate ( $\text{K}_2\text{SiO}_3$ ) will result?

58. From 1500 lb. of salt how many Kg. of sodium carbonate can be obtained by the Leblanc process? How much charcoal and how much limestone will be required?

59. What weight of calcium sulphide will be produced in the manufacture of 1 ton of dry sodium carbonate by the Leblanc process?

60. What weights of salt, ammonia, and carbon dioxide will be necessary to produce 1 ton of  $\text{NaHCO}_3$  by the Solvay process?

61. In a case of poisoning, 11.73 g. of arsenic trisulphide were found; to how much arsenic trioxide does this correspond?



62. If I wish to make ferrous sulphide, how many g. of sulphur should I mix with 56 g. of iron filings, and how much ferrous sulphide should result?

63. How much hydrogen and how much zinc chloride should result from treating 25 g. of zinc with a sufficient quantity of hydrogen chloride?

64. What weight of oxygen is needed to burn a diamond which weighs half a gr.? What will the  $\text{CO}_2$  formed weigh?

65. How much sulphuric acid will neutralize 50 lb. of sodium hydroxide?

66. How much lead is needed to form 2 Kg. of lead nitrate?

67. How many g. of  $\text{HNO}_3$  will 140 g. of  $\text{NH}_4\text{NO}_3$  give?

68. How many g. of iodine in 166 g. of KI?

69. How many tons of pyrite containing 39.2 % of available sulphur are needed to make 4000 tons of sulphuric acid of sp. gr. 1.730 containing 80 % pure  $\text{H}_2\text{SO}_4$  and allowing for no losses?

70. What weight of iron rust may be obtained with a supply of 10 g. of oxygen?

71. How much  $\text{MnO}_2$  is needed to make 125 g. of chlorine from HCl?

72. What weight of ammonium chloride, when acted upon by calcium hydroxide, is required to produce 17 g. of ammonia, and what weight of calcium chloride is formed at the same time?

73. How much "laughing gas" may be made from 80 g. of  $\text{NH}_4\text{NO}_3$ ?

74. How much KI is needed to prepare 63.5 g. of iodine?

75. How much  $\text{K}_2\text{CO}_3$  and  $\text{Ca}(\text{OH})_2$  will give a Kg. of KOH?

76. Find the weight of Hg and O from decomposing 10 g. of  $\text{HgO}$ .

77. How many g. of  $\text{NH}_4\text{NO}_3$  must be used to produce 20 g. of  $\text{N}_2\text{O}$ ?

78. How much phosphorus is there in 1 ton (2000 lb.) of bone ash?

79. What weight of zinc will be required to decompose 10,000 lb. of sulphuric acid?

80. What weight of zinc and of sulphuric acid is necessary to prepare 50,000 l. of hydrogen at  $+31^\circ \text{C}$ . and 758 mm. pressure?

81. One Kg. of phosphorus is converted into phosphoric anhydride. What weight of phosphoric acid will this yield?

82. Find the g. of each component in 76 g. of  $\text{HNO}_3$ . How many g. of nitric oxide can be set free by the action of 252 g. of  $\text{HNO}_3$  on copper?

83. What weight of sulphur is contained in 100 g. of pyrite?

84. How much silver is contained in 100 g. of an impure specimen of silver chloride which is 33 % sand?

85. What weight of oil of vitriol of 97% can be made from 1000 Kg. of sulphur?

86. What weight of oxygen is necessary to burn the sulphur derived from the decomposition of 1 g. of sulphurous anhydride, and what is the weight of the product?

87. Calculate the weight of tin and hydrochloric acid necessary to produce 16 g. of hydrogen.

88. How much sodium carbonate and calcium hydroxide are needed to make a Kg. of sodium hydroxide?

89. Find the weight of each of the products formed by the complete combustion of 52 g. of turpentine.

90. A certain weight of  $\text{MnO}_2$  is heated till decomposed; if the residue weighs 149 g., what weight of oxygen was evolved?

91. How many g. of  $\text{CaCO}_3$  must be used to prepare 22 g. of carbon dioxide by the action of  $\text{HCl}$ ?

92. If 2 g. of silver are dissolved in nitric acid and half a g. of pure, dry sodium chloride is added, what percentage of the silver remains in solution?

93. How much potassium, by its action upon water, is required to furnish  $2\frac{1}{2}$  g. of hydrogen?

94. Find the number of g. of  $\text{HCl}$  that can be set free by the complete action of 10 g. of  $\text{H}_2\text{SO}_4$  on common salt.

95. The ammonia obtained from 20 Kg. of ammonium chloride is united with sulphuric acid to form the neutral salt. What is the weight of the product?

96. How many lb. of limestone are needed to produce 1 ton of quicklime?

97. To obtain 15 g. of bromine, how much  $\text{MnO}_2$ ,  $\text{KBr}$ , and  $\text{H}_2\text{SO}_4$  should be used?

98. What weight of a gas mixture known as "water gas" can be obtained from 24 lb. of carbon and the necessary steam?

99. What is the weight of  $\text{BaO}$  in 1.5 g. of barium carbonate?

100. How many g. of silver will 5 g. of sodium bromide precipitate from a solution of silver in nitric acid?

101. If a solution containing 50 g. of lead nitrate is precipitated by hydrogen sulphide, what will be the weight of the precipitate?

102. If a solution containing 50 g. of copper sulphate is precipitated by hydrogen sulphide, what will be the weight of the precipitate?

103. How much sulphuric acid could be produced from the sulphur dioxide arising from the combustion of 1 ton of sulphur?

104. How much sulphuric acid could be produced from the sulphur dioxide arising from the combustion of 1 ton of pure pyrite?

105. If 100 cc. of a solution of barium chloride that contains 20 g. of the salt in 1 l. is precipitated by sulphuric acid, what weight of  $\text{BaSO}_4$  will be formed?

106. How much potassium chlorate can be made from 150 g. of potassium hydroxide according to the following reaction:



107. How much  $\text{AgNO}_3$  can be obtained from 15 g. of  $\text{Ag}$ , and how much  $\text{H}_2\text{O}$  and how many g. of  $\text{NO}$  will be formed?



108.  $\text{AsH}_3$  is decomposed into its elements. How many mg. of each element from 550 cc. of  $\text{AsH}_3$ ?

109. How much hydrogen potassium carbonate is required to give 1.98 g. of carbon dioxide?

110. How much manganese dioxide is required to charge a wedge-shaped gas bag, 1 m. high and wide and  $\frac{1}{2}$  m. basal thickness, with oxygen at  $+15^\circ \text{C}.$ ?

111. One g. of  $\text{Ca}(\text{OCl})_2$  is boiled with water and  $\text{CuO}$ . What weight of oxygen is evolved?

112. A solution contains 30 g. of silver nitrate. How much common salt is required to decompose the silver nitrate, and how much silver chloride is produced?

113. If 1 Kg. of  $\text{HNO}_3$  is needed, what weights of materials are required to make it?

114.  $\text{CHKO}_2$  (potassium formate) +  $\text{KOH} = \text{K}_2\text{CO}_3 + \text{H}_2$ . In the above equation, if 1 Kg. of  $\text{CHKO}_2$  is used, find the weight of gas evolved.

115. How much hydrochloric acid can be obtained by treating 1 Kg. of common salt with sulphuric acid? How much sulphuric acid will be needed?

116. A piece of potassium is thrown on water; the  $\text{KOH}$  will just neutralize 50 cc. of a solution of  $\text{H}_2\text{SO}_4$  containing 98 g. Find the weight of potassium used.

117. If 2 g. of  $\text{Ag}_2\text{O}$  are thrown into hydrogen peroxide, what weight of gas is evolved?

118. If 200 lb. of nitre and enough  $\text{H}_2\text{SO}_4$  are heated together, what weight of  $\text{HNO}_3$  is given off?

119. What weight of  $\text{CO}_2$  is needed to convert 50 tons of "soda" crystals into dicarbonate of soda?

120. A diamond weighing 0.3 g. is burned in a jar of oxygen. How much  $\text{CaCO}_3$  would be formed by shaking the contents of flask after combustion with lime-water?

121. A certain amount of  $\text{H}_2\text{SO}_4$  requires 10 g. of  $\text{BaCl}_2$  to precipitate it completely. Find the weight of acid used.

122. How much water must be added to 100 g. of  $\text{P}_2\text{O}_5$  to form orthophosphoric acid?

123. A copper coin liberates from sulphuric acid 22 g. of  $\text{SO}_2$ . Find the weight of the coin.

124. How much carbon heated in the air will give 14 g. of  $\text{CO}_2$ ?

125. 13 g.  $\text{C}_6\text{H}_6$  is burned in air. Find the weight of oxygen used and the weight of the gaseous products.

126. What weight of calcium carbide ( $3\text{C} + \text{CaO} = \text{CaC}_2 + \text{CO}$ ) will 600 lb. of lime make? How much carbon is needed?

127. Hydrogen is passed over 2.48 g. of heated  $\text{CuO}$  and the weight is 2.24 g. The water formed weighs 0.27 g. Calculate the weight of H and O.

128. How much  $\text{KCl}$  can be obtained from 200 g.  $\text{KClO}_3$  containing 12% of impurities? Find weight of oxygen given off.

129. Iron dissolved in hydrochloric acid gives 66 cc. of hydrogen. Find the weight of iron used.

130. Water is decomposed and the oxygen is burned with pure carbon, giving 44 g. of  $\text{CO}_2$ . How much water was used?

131. One Kg. of  $\text{NaNO}_3$  is treated with oil of vitriol. Find the weight of aqua fortis produced.

132. How much fluorspar will be needed to unite with 100 g. of  $\text{H}_2\text{SO}_4$ ?

133. If 10 g. of carbon are heated with 67 g. of  $\text{CO}_2$ , what weight (a) of CO is formed; (b) of residue, if any?

134. To get 76 Kg. of oxygen, how much air is needed?

135. In 300 lb. of bone ash are contained: (a) how many lb. of oxygen; (b) how much calcium?

136. If the bones of a man weigh 26 lb. and contain 60 %  $\text{Ca}_3(\text{PO}_4)_2$ , find (a) the weight of phosphorus; (b) the value of the skeleton to make phosphorus pentoxide at \$3 a pound.

137. If 4 Kg. of  $\text{Na}_2\text{CO}_3$  are heated with carbon, what is the weight of sodium produced and of carbon used?

138. How many g. of oxygen and of hydrogen can be obtained by the decomposition of 27 g. of water?

139. How many g. of oxygen can be obtained by the decomposition of 100 g. of mercuric oxide?

140. If 3 g. of urea are warmed with  $\text{KNO}_3$  and hydrogen sulphate, what weights of gases are given off?  
 $\text{CON}_2\text{H}_4 + \text{O}_3 = \text{N}_2 + 2 \text{H}_2\text{O} + \text{CO}_2$ .

141. Calculate the weight of iron that would be dissolved by 100 g. of a solution of hydrochloric acid containing 20 % by weight of the gas.

142. Calculate the weight of zinc sulphate that would be produced by dissolving 10 g. of zinc in sulphuric acid.

143. How much iodine can be obtained from 236 g. of potassium iodide?

**144.** What weights of iron, iodine, and  $K_2CO_3$  are needed to make 347 g. of KI?

**145.** What is the weight of potassium chlorate yielded by the chlorine evolved from 100 tons of manganese ore containing 60 % of the dioxide?

**146.** What weight of potassium bromate can be obtained by neutralizing 520 g. of bromine with potash?

**147.** A manufacturer of bleaching powder requires 10 tons of chlorine. How much salt, manganese ore containing 59 % of the dioxide, and sulphuric acid containing 58 % of real acid will he need?

**148.** What weight of  $MnO_2$ , when heated, will yield 1 g. of oxygen?

**149.** If 2000 g. Cu are heated in air, what weight of oxygen will be used and what weight of CuO will be produced?

**150.** I require 2 Kg. of oxygen; how much (a) mercuric oxide, (b) potassium chlorate, and (c) manganese dioxide, and (d) sulphuric acid shall I need?

**151.** How much  $KMnO_4$  is needed to furnish 1 lb. of oxygen?

**152.** If 132.74 Kg. of hydrogen are needed to inflate a balloon, what weight of zinc and sulphuric acid will be required to produce this quantity of gas?

**153.** Since 77 % of the weight of the air, freed from moisture and  $CO_2$ , consists of nitrogen, calculate the weight of (a) metallic copper, and (b) of phosphorus required to abstract the oxygen from 1 lb. of air.

**154.** In burning 17 g. of alcohol, find the weight of the products.

**155.** How much  $\text{NH}_4\text{NO}_3$  would produce enough  $\text{N}_2\text{O}$  for the combustion of 36 g. of carbon?

**156.** How much nitrogen can be produced by the combustion of  $\text{NH}_3$  produced by the action of 15 g. of  $\text{NH}_4\text{Cl}$  on  $\text{NaOH}$ ?

**157.** How much  $\text{K}_2\text{Cr}_2\text{O}_7$  will be needed to convert 10 g. of  $\text{FeCl}_2$  to  $\text{FeCl}_3$ ?

**158.** How many g. of acetic acid are required to neutralize 6 g. of  $\text{K}_2\text{CO}_3$ ?

**159.** If a solution contains 30 g.  $\text{KI}$ , how much chlorine would be needed to liberate all the iodine, and how much  $\text{KCl}$  would result?

**160.** What weight of  $\text{SnCl}_2$  is needed to precipitate completely the gold in 200 g. of  $\text{AuCl}_3$ ?

**161.** If 100 g.  $\text{MnO}_2$  are treated with  $\text{HCl}$  in excess, what weight of chlorine is evolved? If treated with enough  $\text{NaCl}$  and  $\text{H}_2\text{SO}_4$ , how much chloride would be necessary?

**162.** If 300 g. of cinnabar are heated, (a) how much oxygen is needed; (b) what weight of mercury is left?

**163.** If 63 g. of lead are heated, how many g. of  $\text{PbO}$  are produced?

**164.** If 100 g. of copper and 100 g. of sulphur are heated together, what substances will be found after combination and how much of each?

**165.** If 32 g.  $\text{Cu}$ , 103 g.  $\text{Pb}$ , 12 g.  $\text{Mg}$ , and 25 g.  $\text{Fe}$  are each heated in the air till they cease to gain in weight, how many g. will each gain?

**166.** How much iron is needed to throw down all the copper in a  $\text{CuSO}_4$  solution containing 160 g. and what weight of  $\text{FeSO}_4$  will be formed?

**167.** Calculate the weight of air required to burn a ton of coal possessing the following percentage composition: carbon, 88.42; hydrogen, 5.61; oxygen, 5.97.

**168.** What weight of potassium chlorate is needed to furnish oxygen sufficient to burn the hydrogen evolved by the action of water on 200 g. of calcium?

**169.** If 100 g. of pure iron are burnt in excess of (a) oxygen and (b) chlorine, what is the weight of oxide and chloride produced?

**170.** How much nitre and sulphuric acid shall I need to prepare nitric acid enough to neutralize exactly 5 lb. of chalk?

**171.** How much pure zinc will be required to prepare 1 Kg. of hydrogen?

**172.** What weights of NaOH and  $\text{H}_2\text{SO}_4$  are needed to produce 100 g. of  $\text{Na}_2\text{SO}_4$ ?

**173.** How many g. of sulphuric acid and of nitre are required to make 250 g. of nitric acid?

**174.** How much crystallized microcosmic salt must be ignited to furnish a g. of sodium metaphosphate?

**175.** What weights of copper and sulphuric acid are needed to yield 30 g. of sulphurous acid at the standard temperature and pressure?

**176.** What weight of iron is contained in 10 tons of pyrite?

**177.** What weight of silver chloride will be formed by the reaction of 0.2008 g. of sodium chloride with silver nitrate in solution?

**178.** How many tons of coke containing 97% of carbon are required to reduce 388 tons of hematite?

179. How much carbon would be necessary to reduce 9 g. of copper oxide?

180. How much sulphuric acid (80 %) should be procurable from 5 tons of pyrite which carries 44 % of sulphur?

181. Suppose a glass had the formula  $\text{Na}_2\text{O}$ ,  $\text{CaO}$ ,  $6 \text{ SiO}_2$ , how much sodium carbonate and limestone would be necessary to make 250 lb.?

182. If monazite sand contains 4 % of  $\text{ThO}_2$ , how many tons of the sand would be necessary to produce 24,000,000 mantles, if each mantle weighs 6 g.?

183. How many lb. of pig iron containing 95 % Fe can be made from 2000 lb.  $\text{Fe}_2\text{O}_3$ ?

184. How much copper oxide would be used and copper obtained in preparing 3.2 g. of water?

185. How much carbon dioxide and disulphide, respectively, can be produced from 4 lb. of pure charcoal?

186. How much barium dioxide is necessary to make 5 lb. of a 4 % solution of hydrogen dioxide?

187. How much lime is theoretically obtainable from 9 tons of limestone which is 97 % pure?

188. What weight of sodium chloride, when treated with sulphuric acid, will produce 100 g. of sodium sulphate?

189. What weight of sulphuric acid can be manufactured from a ton of pyrite?

190. What mass of water will be needed to convert 142 g. of  $\text{P}_2\text{O}_5$  into (a) hydrogen orthophosphate; (b) hydrogen pyrophosphate; (c) hydrogen metaphosphate?

191. What weight of  $\text{KMnO}_4$  will be needed to convert 139 g. of  $\text{FeSO}_4 \cdot 7 \text{H}_2\text{O}$  into the ferric condition?

192. We need 4711 g. common alum; what weight of "alumina" is needed?

193. How much of each material would be needed to produce 502 g. of "manganese alum"?

194. How much water is necessary to convert 55 g. of  $\text{P}_2\text{O}_3$  into hydrogen phosphite?

195. What mass of oxygen can be obtained by heating (a) 24 g.  $\text{KClO}_3$ ; (b) 174 g.  $\text{MnO}_2$ ; (c) 49 g.  $\text{KClO}_3$  and  $\text{MnO}_2$ ; (d) 100 g.  $\text{HgO}$ ; (e) 200 g.  $\text{Cu}(\text{NO}_3)_2$ ?

196. How many g. of commercial  $\text{HNO}_3$  (containing 68%  $\text{HNO}_3$ ) will be needed to decompose (a) 100 g. marble; (b) 100 g.  $\text{Na}_2\text{CO}_3$ ?

197. What weight of hydrogen can be obtained by the action of 112 g.  $\text{KOH}$  on potassium formate?

198. Find weight of oxygen needed to burn 150 g. of  $\text{CS}_2$ .

199. How many g. arsenic are needed to make 200 g. of arsenious oxide?

200. What weight of magnesium oxide will be produced by burning 0.5 g. of magnesium ribbon?

201. What weight of oxygen will be obtained by heating 26 g. of potassium chlorate?

202. What weight of quicklime can be obtained from 1800 lb. of limestone?

203. How much carbon dioxide may be obtained from 22 g. calcium carbonate?

204. Ten g. of sodium hydroxide are dissolved in water, a volume of hydrochloric acid containing 15 g.



of hydrogen chloride is added, and the mixture is evaporated to dryness. Of what does the residue consist and what is the weight of each constituent?

**205.** What weight of silver nitrate could be obtained by dissolving a ten-cent piece, weighing 2.44 g. and containing 90 % silver, in dilute nitric acid and evaporating?

**206.** Assume that "thermit" contains 75 % iron oxide; how much of the mixture would be required to produce 6 lb. of metallic iron?

**207.** How many pailfuls of water, 12 Kg. each, would be required to slake 250 lb. of quicklime?

**208.** How many lb. of pure calcium cyanamide would be required to produce 40 lb. of ammonia?

**209.** If 30 g. of potassium chlorate are decomposed, the oxygen collected, and magnesium is burned in the oxygen until no gas remains, what weight of magnesium is required?

**210.** What weight of sodium carbonate can be made from 500 Kg. of common salt?

**211.** How much nitrogen tetroxide may be made according to theory from 8 g. of lead nitrate?

**212.** How much iron could be obtained from 40 g. of  $\text{Fe}_2\text{O}_3$ , and what weight of hydrogen would be required to effect this process?

**213.** How much  $\text{AgCl}$  will be formed by the addition of 10 g. of barium chloride to an excess of  $\text{AgNO}_3$ ?

**214.** How much red lead could be made from 800 Kg. of litharge?

**215.** What weight of  $\text{Al}_2\text{O}_3$  will be needed to prepare 94.8 g. of potash alum?

216. How much  $\text{CaSO}_4$  can be formed from 37 g. of  $\text{CaCl}_2$ ?

217. Calculate the amount of  $\text{Ba}(\text{NO}_3)_2$  necessary to precipitate 120 g. of dilute  $\text{H}_2\text{SO}_4$  containing 50 % of water.

218. How many lb. of  $\text{Ag}_2\text{O}$  are needed to make 3100 lb. of oxygen?

219. How much  $\text{K}_2\text{CO}_3$  is needed to precipitate completely 109.5 g. of  $\text{CaCl}_2$ ?

220. What weight of phosphorus is needed to produce 100 g. of  $\text{Mg}_2\text{P}_2\text{O}_7$ ?

221. What weight of zinc, sodium, calcium, iron, and magnesium will be required to produce 10 g. of hydrogen?

222. How many g. of  $\text{CO}_2$  will combine with 100 g. of  $\text{CaO}$  to form  $\text{CaCO}_3$ ?

223. If 560 g. of bromine are treated with  $\text{KOH}$ , what weight of potassium bromate is produced?

224. If 6 g. of carbon and 22 g. of oxygen are heated in a closed tube, what is the weight of the resulting substances?

225. If 294 g.  $\text{K}_2\text{Cr}_2\text{O}_7$  are wanted, what weight of  $\text{K}_2\text{CrO}_4$  will be used?

226. If 5.75 g. of silver nitrate are added to 5.75 g. of a solution of hydrochloric acid containing 10.22 %  $\text{HCl}$ , how much silver is precipitated and how much remains in solution?

227. What weight of oxygen is needed to burn 15 g. of charcoal (90 %  $\text{C}$  and 4 %  $\text{H}$ )?

228. What weight of  $\text{CO}_2$  is needed to convert 90 tons of soda crystals into bicarbonate?

**229.** What weight of chlorine could be obtained by acting upon 20 g. of pure manganese dioxide with hydrochloric acid?

**230.** What weight of oxygen could be obtained by the complete decomposition of 100 g. of pure potassium chlorate? If the chlorate used contained 10 % of its weight of potassium chloride, what would be the difference in the amount of oxygen obtained?

**231.** A solution of nitric acid of sp. gr. 1.46 contains 80 % of  $\text{HNO}_3$ . What weight of this solution is theoretically required to dissolve 10 g. of copper oxide?

**232.** How much  $\text{BaO}_2$  would yield as much oxygen as 250 g. of mercuric oxide?

**233.** When 0.542 g. of a salt of copper had been dissolved in water and precipitated by sodium hydrate, the precipitate was dried and ignited, and it then weighed 0.242 g. What was the percentage of copper in the salt?

**234.** A mixture of 4 g. of sodium oxide and 6 g. of sulphur trioxide will give what weight of sodium sulphate?

**235.** A manufacturer of bleaching powder requires 400 tons of chlorine. How much salt, manganese containing 59 % of the dioxide, and sulphuric acid containing 58 % of real acid will he need?

**236.** What weight of potassium bromate can be obtained by neutralizing 1520 g. of bromine with potash?

**237.** Iodic acid may be obtained by passing a stream of chlorine through water containing iodine in suspension. How much iodine and chlorine will be needed to prepare 100 g. of iodic acid?

**238.** What weight of fluorspar would be required to furnish sufficient hydrogen fluoride (by interaction with sulphuric acid) to convert 5 g. of quartz into silicon fluoride?

**239.** Calculate the weight of chlorine, at standard conditions, necessary to give, by interaction with water, an amount of oxygen that will just suffice for the oxidation of 10 g. of mercury to mercuric oxide.

**240.** What weight of sulphuric acid can be prepared from 100 g. of sulphur?

**241.** Calculate the weight of potassium in a sample of pure sylvite (KCl) which, on being analyzed, gave 2.230 g. of chlorine.

**242.** What weight of copper is present in a sample of pure copper sulphate which, on being analyzed, gave 30.2 g. of sulphur trioxide,  $\text{SO}_3$ ?

**243.** Calculate the percentage purity of a sample of horn silver which, on being analyzed, gave 74.2% of silver.

**244.** When 8.2 g. of crystallized barium chloride and 7 g. of sulphuric acid (70%  $\text{H}_2\text{SO}_4$ ) were brought together in aqueous solution, what weight of barium sulphate was precipitated?

**245.** Compare the weights of aluminum and zinc necessary for the production of equal weights of hydrogen by interaction with an acid.

**246.** Compare the weight of calcium nitride ( $\text{Ca}_3\text{N}_2$ ) (in its interaction with water) and the weight of ammonium chloride (in its interaction with a base) necessary to give the same weight of ammonia.

**247.** What relative weights of cupric oxide and cuprous oxide are procurable from the same weight of copper?

**248.** If 2.4 g. of ammonia reduced 17 g. of hot cupric oxide to copper, calculate the reaction quantity of cupric oxide required per molecule of ammonia.

**249.** If 3 g. of silver nitrate and 1 g. of potassium chloride were brought together in aqueous solution, what weight of silver chloride would be precipitated?

**250.** If 12 g. of an alloy of aluminum and zinc (containing  $33\frac{1}{3}\%$  of zinc) were placed in a vessel containing 180 g. of hydrochloric acid (35 % HCl), what volume of hydrogen, at standard conditions, would be liberated?

**251.** A specimen of silver containing 3 % copper weighed 9.8 g. After solution in nitric acid, an excess of sodium chloride was added to it. Calculate the weight of the silver chloride precipitated.

**252.** What weight of potassium hydroxide may be prepared by the action of 100 g. of potassium upon water?

**253.** What weight of potassium will be required in the preparation of 20 g. of potassium carbonate?

**254.** What weight of magnesium chloride may be obtained by the action of hydrochloric acid upon 10 g. of magnesium carbonate? What weight of carbon dioxide will be liberated?

**255.** What weight of sulphur dioxide can be obtained by the action of an acid upon 250 g. of sodium sulphite?

**256.** If sodium nitrate, ammonium nitrate, and potassium nitrate were the same price per lb., which would be cheapest to use for preparing nitric acid, and why?

**257.** How much sulphuric acid and potassium nitrate would be required in order to prepare 100 g. of nitric acid?

**258.** What weight of chrome-alum may be obtained from 20 g. of crystallized potassium sulphite and an excess of chromium sulphate?

**259.** What weight of ammonium-magnesium phosphate ( $\text{NH}_4\text{MgPO}_4 \cdot 6 \text{H}_2\text{O}$ ) could be formed from a solution containing 50 g. of crystallized magnesium sulphate and an excess of ammonia and sodium phosphate?

**260.** What weight of iron-ammonium alum may be formed when 12 g. of ammonium sulphate and 30 g. of ferric sulphate are brought together in concentrated aqueous solution?

**261.** When 100 g. of mercury and 20 g. of sulphur are rubbed together, what weight of mercuric sulphide may be formed?

**262.** A solution containing 5 g. of potassium iodide is precipitated with silver nitrate. What will be the weight of the precipitate of silver iodide?

**263.** What quantities of nitre and Chili saltpeter, respectively, will be required to obtain the maximum quantity of nitric acid by reaction with 140 Kg. of 97 % sulphuric acid?

**264.** Calculate the weight of air required to burn 1 ton of coal possessing the following percentage composition: carbon, 88.42; hydrogen, 5.61; oxygen, 5.97.

**265.** How much marble and hydrochloric acid containing 22 % HCl are needed to yield 10 g. of carbon dioxide?

**266.** A piece of metallic iron immersed in a solution of copper for a long time, in order to precipitate all the copper, was found to have lost in weight 0.52 g. What was the amount of copper in the solution?

**267.** A solution of mercuric chloride contains 80 g. of the salt per l. ; sodium hydrate is added in excess to 175 cc. of the solution ; what will the precipitate weigh if collected and dried?

**268.** How many tons of oil of vitriol containing 70 %  $\text{H}_2\text{SO}_4$  are needed to convert 100 tons of salt into salt cake?

**269.** What increase in weight will occur on burning 10 g. of phosphorus in a tube through which oxygen is passed, supposing that none of the product is lost?

**270.** How many g. of iodine will be liberated from an excess of a saturated solution of potassium iodide, into which the gas evolved from heating 4.34 g. of manganese dioxide with hydrochloric acid is passed?

**271.** What weight of potassium dichromate must be heated with hydrochloric acid in order to evolve sufficient chlorine to liberate the iodine from 1.656 g. of potassium iodide?

## CHAPTER VII

### Volumes from Equations

1. What weight of 95 % alcohol is needed to yield 20 m.<sup>3</sup> of ethylene at + 94° F. and 730 mm.?

2. A l. of water is acted upon by phosphorus tri-bromide; what will be the weight of the products and the volumes of the gaseous ones at + 4° C. and 760 mm.?

3. A tank  $\frac{1}{2}$  m. long,  $\frac{1}{4}$  m. wide, and  $\frac{1}{5}$  m. deep is filled with water and the water decomposed. What volumes of hydrogen and of oxygen result, if measured at - 13° C. and 790 mm.?

4. If 130 l. of CO<sub>2</sub> are passed through a KOH solution, how many g. of KOH will be converted into K<sub>2</sub>CO<sub>3</sub>?

5. If 100 g. of Na<sub>2</sub>CO<sub>3</sub> are treated with HCl, how many g. of salt and how many l. of CO<sub>2</sub> will be formed?

6. If 1 m.<sup>3</sup> of CO<sub>2</sub> is absorbed by Ca(OH)<sub>2</sub>, what weight of CaCO<sub>3</sub> will be formed?

7. An ore contains 67.4 % of MnO<sub>2</sub>; what volume of chlorine could be obtained by treating 300 tons of this ore with HCl?

8. How much acetic acid must be decomposed in order to obtain 100 l. of CH<sub>4</sub>?



9. From 100 lb. of pure limestone how many l. of  $\text{CO}_2$  can be obtained? What weight of lime?

10.  $2 \text{KNO}_3 + 3 \text{C} + \text{S} = 3 \text{CO}_2 + \text{N}_2 + \text{K}_2\text{S}$ . In the above equation find the weights and volumes of the gases produced and the weight of carbon and sulphur when 10 g. of  $\text{KNO}_3$  are used.

11. How much phosphorus can be burned in 4 l. of "laughing gas" measured at  $+14^\circ \text{C}$ ?

12. What weight of  $\text{HBr}$  will result if 1  $\text{m}^3$ . of hydrogen is caused to unite with bromine vapor by passing the mixture over a catalytic agent?

13. How many g. of zinc are necessary for the production, by the action of muriatic acid, of 90 l. of hydrogen measured under standard conditions?

14. If 19 g. of  $\text{CS}_2$  are burned, what are the weights and volumes of the products?

15.  $3 \text{Cu}_2\text{O} + 14 \text{HNO}_3 = 6 \text{Cu}(\text{NO}_3)_2 + 7 \text{H}_2\text{O} + 2 \text{NO}$ . 100 g. of  $\text{Cu}_2\text{O}$  are used. Find volume of the gas produced.

16. What volume of nitrous oxide measured at  $0^\circ \text{C}$ . and 750 mm. would be evolved by the decomposition of 10 g. of ammonium nitrate?

17. When 12 g. of carbon burn in the air, find the volume of the resulting gas at 1 atmosphere and  $0^\circ \text{C}$ .

18. A balloon of 100,000  $\text{ft}^3$  capacity is to be filled with hydrogen; how many lb. of zinc and sulphuric acid will be needed?

19. How much water can be decomposed by 20.7 g. of sodium, and what volume of hydrogen would be set free?

20. What volume of hydrogen will unite with 24 g. of oxygen to form water? What volume of hydrogen and of oxygen could be obtained by the electrolysis of 10 g. of water?

21. With what weight of hydrogen will 30 g. of oxygen unite to form water?

22. With how much sulphuric acid must zinc be treated in order to obtain 16,250 cc. of hydrogen? Find weight of  $\text{ZnSO}_4$ .

23. If a tube containing copper oxide weighs before hydrogen is passed through it 15.846 g., and after the hydrogen has been passed 12.239 g., how many l. of hydrogen have united with the oxygen of the copper oxide? How much water has been formed?

24. Find the number of l. of gas given off by the action of 130.8 g. of Zn on  $\text{H}_2\text{SO}_4$ .

25. Given 10 Kg. of iron to be acted upon by sulphuric acid, what weight of acid is needed, and what is the volume of hydrogen secured at  $-6^\circ \text{C}$ . and 780 mm. pressure?

26. How many l. of hydrogen at  $0^\circ \text{C}$ . and 760 mm. pressure may be secured from 2000 g. of  $\text{HCl}$ ?

27. What weight of  $\text{NH}_4\text{NO}_3$  must be used to give 45 l. of  $\text{N}_2\text{O}$  under standard conditions?

28. How many l. of hydrogen, under standard conditions, will result from the electrolysis of 18 g. of water?

29. How many g. of sulphur must be burned to yield 100 l. of sulphur dioxide under standard conditions?

30. What would be the volume, under standard conditions, of the hydrogen liberated in the decomposition of 30 g. of water by means of sodium?

31. What volume of hydrochloric acid, under standard conditions, can be obtained by the action of sulphuric acid upon 150 g. of salt?

32. What volume of chlorine, measured under standard conditions, will convert 10 g. of potassium hydroxide into chloride and chlorate according to the reaction:



33. How many cc. of marble,  $\text{CaCO}_3$  (sp. gr. 2.70), must be dissolved in  $\text{HCl}$  to give 5 l. of  $\text{CO}_2$ ?

34. How many g. of air, approximately, ought it to take to burn 10 l. of gaseous  $\text{C}_3\text{H}_8$ , if  $\frac{1}{5}$  of the volume of the air is oxygen?

35. (a) How many Kg. of  $\text{CO}_2$  will form in the combustion of a cylindrical tank of liquid acetylene,  $\text{C}_2\text{H}_2$ , which is 15 cm. in diameter and 18 dm. high, if its sp. gr. is 0.8? (b) If the  $\text{CO}_2$  is absorbed by lime water, how many Kg. of  $\text{CaCO}_3$  would form? (c) How many days will this tank of  $\text{C}_2\text{H}_2$  serve to light a house with 6 gas jets, each running 5 hours and burning  $\frac{1}{2}$  ft.<sup>3</sup> per hour, if 1 ft.<sup>3</sup> equals 27,000 cc.?

36. What volume of sulphur dioxide would result from heating in the air 1 ton of pure iron pyrites, assuming that all of the sulphur in the pyrites is converted into sulphur dioxide?

37. What volume of hydrogen sulphide will be formed upon treating 40 g. of ferrous sulphide,  $\text{FeS}$ , with hydrochloric acid?

38. What volume and what weight of sulphur dioxide will be formed upon burning 1 l. of hydrogen sulphide?

39. Under a barometric pressure of 740 mm. at  $+20^{\circ}$  C., what weight of ammonium nitrate must be decomposed to generate sufficient nitrous oxide to fill a balloon holding 200 l.?

40. What weight of carbon will be required to completely convert into carbon dioxide 20 l. of oxygen measured under a pressure of 780 mm. of mercury at  $+30^{\circ}$  C.? What volume of carbon dioxide, under the same conditions, will be formed?

41. Excess of carbon is thrown into 100 g. of fused  $\text{KNO}_3$ . What volume of nitrogen and of  $\text{CO}_2$  is evolved?



42. Find the number of l. of water needed to slake a bin of lime containing 1376 Kg.

43. It is desired to fill with oxygen at  $+35^{\circ}$  C. and 530 mm. a gas-holder, the capacity of which is 45 l.; what weight of  $\text{KClO}_3$  is requisite?

44. A Kg. of  $\text{KClO}_3$  will yield what weight of oxygen; what volume at  $+24^{\circ}$  C. and 736 mm.?

45. If 256 g. of sodium peroxide are decomposed by water, what is the volume of the oxygen secured at  $+21^{\circ}$  C. and 710 mm.; at  $-80^{\circ}$  C. and 1410 mm.?

46. What volume of hydrogen may be secured from 12 Kg. of water, with the aid of potassium, the hydrogen to be measured at  $+25^{\circ}$  C. and 780 mm.?

47. What weights of water and of potassium are needed to generate 8 l. of hydrogen at  $+25^{\circ}$  C. and 760 mm.?

48. How many l. of hydrogen at  $+22^{\circ}$  C. and 714 mm. will 98 g. of hydrochloric acid yield?

49. How much zinc is needed to prepare 100 l. of hydrogen at  $0^{\circ}\text{C}$ . and 740 mm. ?

50. A m.<sup>3</sup> gas-holder is to be filled with oxygen at  $+100^{\circ}\text{C}$ . and 721 mm. What weight of  $\text{Pb}(\text{NO}_3)_2$  is needed to prepare it?

51. If 10 l. of hydrogen at  $+15^{\circ}\text{C}$ . are burned, what volume of steam at  $+300^{\circ}\text{C}$ . is formed?

52. How many l. of chlorine can be obtained by treating 50 g. of manganese dioxide with hydrochloric acid?

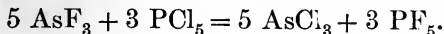
53. What volume of arsine will result when 150 mg. arsenic trioxide is acted upon by nascent hydrogen?

54. How much lead sulphide can be precipitated by 17 l. of hydrogen sulphide?

55. What volume of sulphur vapor would result from the decomposition of a l. of  $\text{H}_2\text{S}$  at  $+500^{\circ}\text{C}$ . if the density of S is 96 and its atomic weight is 32?

56. What volume of zinc vapor will unite with 300 cc. of oxygen to form zinc oxide? Zn has vapor density of 32.5; atomic weight 65.

57. How much phosphoric fluoride by volume can be obtained from 100 g. of phosphorus pentachloride?



Supposing all the products to be gases, find the volumes.

58. How many cc. of solid arsenic (sp. gr. 5.73) could be obtained from 1250 cc. of arsine at a temperature of  $+105^{\circ}\text{C}$ . ?

59. If 425 l. and 328 cc. of oxygen at  $+24^{\circ}\text{C}$ . and 658 mm. are wanted, what weight of  $\text{BaO}_2$  is needed to make that amount?

60. If 752 l. of oxygen at  $+19^{\circ}\text{C}$ . and 729 mm. are wanted, what weight of water must be decomposed to secure that amount, and what volume of hydrogen is obtained at the same time?

61. Three l. of water are to be decomposed. What volumes of hydrogen and oxygen result at  $-21^{\circ}\text{C}$ . and 790 mm.?

62. The hydrogen secured from 100 lb. of sulphuric acid is burned. What weight of water results?

63. The hydrogen derived from 2 l. of water is burned. What is the weight of the product?

64. The hydrogen derivable from 98 Kg. of pure sulphuric acid is to be burned; what is the weight of the product? What is its volume at  $+4^{\circ}\text{C}$ . and 760 mm.; at  $+150^{\circ}\text{C}$ . and 754 mm.?

65. How much ammonium nitrate is needed to prepare 100 l. of nitrous oxide at  $-5^{\circ}\text{C}$ . and 600 mm.?

66. How much copper is needed to prepare 100 l. of nitric oxide at  $-100^{\circ}\text{C}$ . and 760 mm.?

67. What weight of phosphorus, if all is converted, is necessary to produce 100 l. of phosphine at  $+68^{\circ}\text{F}$ . and 720 mm.?

68. What volumes of hydrogen and oxygen, respectively, result from the decomposition of 100 l. of water vapor at  $+200^{\circ}\text{C}$ .?

69. What weight of carbon is necessary to reduce 20 g. of carbon dioxide to carbon monoxide? How many l. of air at  $+22^{\circ}\text{C}$ . and 760 mm. are required to burn the monoxide thus formed to the dioxide?

70. What volume of oxygen, measured under standard conditions, will be evolved when 108 g. of mercuric oxide are decomposed by heating?

71. If 15 Kg. of  $\text{H}_2\text{SO}_4$  are worked up by the aid of copper into sulphur dioxide, what weight of Cu is needed, and what weights and volumes of the products result at  $+35^\circ\text{C}$ . and 730 mm.?

72. A l. of chlorine measured at  $+25^\circ\text{C}$ . and 753 mm. is used to expel the iodine from potassium iodine. What weight of iodine is expelled?

73. Find, under standard conditions, the volume of the gases resulting from the electrolysis of 72 g. of water.

74. If 50 gal. of carbon monoxide are burned, what volume of oxygen at  $+48^\circ\text{C}$ . and 675 mm. is necessary, and what volume of carbon dioxide is secured?

75. One hundred g. of chlorine are to be united with hydrogen. What volume of hydrogen is needed at  $+150^\circ\text{C}$ . and 735 mm., and what volume of hydrochloric acid gas results?

76. The hydrogen sulphide secured from 55 Kg. of ferrous sulphide is decomposed. What volume of hydrogen results at  $0^\circ\text{C}$ . and 760 mm.; at  $+75^\circ\text{C}$ . and 780 mm.?

77. If 1500 g. of HCl are decomposed, what volumes of H and of Cl are secured at  $+28^\circ\text{C}$ . and 790 mm.?

78. The HCl securable from 550 g. of common salt is decomposed. What volumes of H and Cl result at  $-20^\circ\text{C}$ . and 778 mm.?

79. The water resulting from the combustion of 1 g. of hydrogen is decomposed. What are the volumes of H and O at  $+423^\circ\text{C}$ . and 787 mm.?

80. What weight of material is required to secure 500 l. of ammonia at  $0^{\circ}$  C. and 700 mm.?

81. If 500 g. of oxalic acid are decomposed with sulphuric acid, what volumes of carbon monoxide and dioxide result if measured at  $-21^{\circ}$  F. and 640 mm. are obtained?

82. How much ferrous sulphide is needed to prepare 100 l. of hydrogen sulphide at  $-10^{\circ}$  C. and 800 mm.?

83. If 13,720 cc. of hydrogen chloride at  $-10^{\circ}$  C. and 730 mm. are decomposed by electricity, what are the volumes and weights of the products?

84. What weight of calcium carbide must be employed if we wish to fill with acetylene gas a reservoir, 12 m. by 10 m. by 60 cm., at  $+28^{\circ}$  C. and 760 mm.?

85. What volume of nitrous oxide, measured at  $0^{\circ}$  C. and 780 mm., may be obtained from 10 Kg. of ammonium nitrate?

86. How many l. of chlorine at  $+21^{\circ}$  C. and 750 mm. are needed to manufacture 10 Kg. of potassium chlorate, provided there is no loss?

87. What weight of calcium carbide must be employed to fill with acetylene gas a gas-holder that contains 10,000 m.<sup>3</sup> at  $+18^{\circ}$  C. and 750 mm.?

88. The hydrogen chloride secured from 210 Kg. of sodium chloride is employed for preparing hydrogen. What is the volume procurable at  $+1200^{\circ}$  C. and 2.5 atmospheric pressure?

89. What volume of hydrogen at  $+40^{\circ}$  C. and 715 mm. will 1 Kg. of sodium liberate from water?



90. What volume of arsine at  $+20^{\circ}\text{C.}$  and 760 mm. results from the action of nascent hydrogen upon 10 g. of arsenious oxide?

91. What volume of hydrogen sulphide at  $+110^{\circ}\text{C.}$  and 660 mm. may be made from 210 Kg. of ferrous sulphide?

92. What volume of  $\text{NH}_3$  may be obtained from 430 g. of  $\text{NH}_4\text{Cl}$ ?

93. What volume of oxygen is needed at  $0^{\circ}\text{C.}$  and 760 mm. to burn completely 42 l. of hydrogen sulphide measured at  $+20^{\circ}\text{C.}$  and 780 mm.?

94. A container measuring 50 cm. by 9 dm. by 300 mm. is filled with  $\text{HCl}$  gas at  $+20^{\circ}\text{C.}$  and 740 mm. A precisely similar measure of ammonia is introduced; what weight of ammonium chloride is formed? What is left over and how much?

95. What volume of gaseous products, measured at  $+150^{\circ}\text{C.}$  and 760 mm., is secured by the decomposition by heat of 2 Kg. of ammonium nitrate?

96. One Kg. of phosphorous acid is to be made by acting upon phosphorus tribromide with water. What weight of the tribromide is needed, and what volume of hydrogen bromide is produced?

97. If 1300 l. of hydrogen sulphide at  $+88^{\circ}\text{C.}$  and 742 mm. are decomposed, what weight of sulphur results? What is the volume of the resultant sulphur measured at  $+1450^{\circ}\text{C.}$  and 760 mm.?

98. What volumes of hydrogen and nitrogen, measured at  $-10^{\circ}\text{C.}$  and 730 mm., result if we decompose by electricity all of the ammonia that may be secured from 1000 g. of ammonium sulphate?

99. Given 20 l. of sulphur vapor at  $+500^{\circ}\text{C}.$ , what quantity, by weight, of sulphur trioxide can be made from it?

100. To secure 100 Kg. of  $\text{H}_2\text{S}$  at  $-10^{\circ}\text{C}.$  and 750 mm., what weight of  $\text{Na}_2\text{S}$  and of hydrochloric acid is needed? And what other products are secured?

101. How many g. of sulphur are needed to produce 110 l. of sulphur dioxide at  $+360^{\circ}\text{F}.$  and 739 mm.?

102. If 10,000 m.<sup>3</sup> of hydrogen sulphide at two atmospheres pressure and  $+10^{\circ}\text{C}.$  are wanted, what weight of materials is needed to make it?

103. What volume of hydrogen chloride is formed when 10 l. of chlorine combine with hydrogen?

104. What volume of nitric oxide, measured at 743 mm. and  $+18^{\circ}\text{C}.$ , will be produced by treating 18 g. of metallic copper with an excess of nitric acid?

105. How many l. of oxygen are required to burn 3 l. of  $\text{AsH}_3$ , and what will be the weight of each of the products?

106. What volume of carbon dioxide, measured at 750 mm. pressure and  $+20^{\circ}\text{C}.$ , will be formed when 17 g. of a candle, 85 % C and 15 % H, is burned?

107. A steel cylinder of 4 ft.<sup>3</sup> capacity is to be filled with carbon dioxide under a pressure of 150 lb. to the in.<sup>2</sup>. What weight of marble and hydrochloric acid would be needed to produce the necessary amount of gas?

108. How many l. of acetylene can be obtained from 50 g. of calcium carbide that is 93 % pure, if the gas is evolved at a temperature of  $+40^{\circ}\text{C}.$  and a pressure of  $1\frac{1}{2}$  atmospheres?

**109.** What volume of sulphur dioxide at  $+20^{\circ}\text{C}$ . and 740 mm. can be obtained by the action of 20 g. of sulphuric acid upon copper?

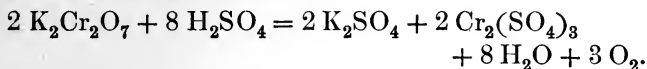
**110.** How many l. of carbon dioxide would result from burning 5.384 g. of carbon?

**111.** What volume of oxygen will be required to burn 1 Kg. of carbon?

**112.** What volume of air, of 21 % oxygen by volume, is needed to burn completely 1 ton of anthracite coal, assumed to be pure carbon?

**113.** How many l. of chlorine can be obtained from 34 g. of salt?

**114.** What volume of oxygen, measured at  $+15^{\circ}\text{C}$ . and 772 mm. pressure, can be obtained from 100 cc. of sulphuric acid (sp. gr. 1.84)?



**115.** How many l. of air will be required to burn 5 g. of phosphorus?

**116.** If 10 l. of hydrofluoric acid gas were made from  $\text{CaF}_2$  and  $\text{H}_2\text{SO}_4$ , how much  $\text{CaSO}_4$  was made at the same time?

**117.** What volume of nitrous oxide, measured at  $0^{\circ}\text{C}$ . and 750 mm., would be evolved by the decomposition of 10 g. of ammonium nitrate?

**118.** What volume of carbon dioxide, under standard conditions, can be obtained from exactly 10 g. of calcium carbonate?

**119.** If 12 g. of carbon are burned to carbon dioxide, what will be the volume of the gas compared with 1 g. of hydrogen at the same temperature and pressure?

120. From 2078 g. of sodium chloride what volume of chlorine can be obtained?

121. If 9.6 g. of sulphur are heated in hydrogen, what volume of hydrogen sulphide is formed?

122. What volume of hydrogen, under normal conditions of temperature and pressure, can be obtained from 10 g. of pure zinc?

123. Calculate the number of g. of ferrous carbonate required to react with sulphuric acid in order to set free 60 l. of carbon dioxide.

124. If 40 g. of Ca react with water, what is the weight and volume of hydrogen?

125. If 600 g. of  $\text{MnO}_2$  are decomposed by heat, what is the volume of O at  $+13^\circ \text{C}$ . and 781 mm.?

126. If 55.8 l. of hydrogen at  $0^\circ \text{C}$ . and 760 mm. are required, how much zinc and KOH are needed for its formation?

127. If 168 g. of  $\text{MgCO}_3$  are heated and the  $\text{CO}_2$  is passed into KOH solution, what weight of  $\text{K}_2\text{CO}_3$  will be formed?

128. If 147 g.  $\text{K}_2\text{Cr}_2\text{O}_7$  are heated with  $\text{H}_2\text{SO}_4$ , what will be the volume and weight of gas evolved?

129. How much alcohol should be burned to give 13 l. of steam?

130. If 1000 cc. of  $\text{H}_2\text{S}$  burn in the air, find (a) weight and volume of oxygen used, and (b) products formed.

131. If 16 l. of  $\text{SO}_2$  are produced by burning a piece of sulphur, how heavy was the sulphur?

132. What volume of chlorine is required to unite with 71 g. of gold to produce auric chloride?

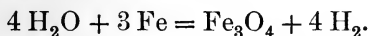
**133.** How many l. of oxygen at  $0^{\circ}$  C. and 760 mm. could be obtained from a pailful of water, the water weighing 12 Kg.?

**134.** How much salt is necessary to produce 480 g. of chlorine, and how much space would be filled by that amount of chlorine at  $+20^{\circ}$  C. and 755 mm. pressure?

**135.** The sp. gr. of acetylene is 0.92. What volume would be occupied, at  $+20^{\circ}$  C. and 750 mm., by the gas generated from 480 g. of calcium carbide, 95% pure?

**136.** What weight of potassium chlorate is necessary to yield 6 l. of oxygen measured over water at  $+18.1^{\circ}$  C. and 759.9 mm.?

**137.** If 2 g. of steam are passed over red-hot iron, what volume of hydrogen at  $+10^{\circ}$  C. and 770 mm. is formed?



**138.** What weight of sodium would be necessary to liberate 75 cc. of hydrogen at  $0^{\circ}$  C. and 760 mm. by reacting with water?

**139.** What volume of oxygen at  $0^{\circ}$  C. and 760 mm. would be liberated by heating 1.05 g. of mercuric oxide?

**140.** What volume of hydrogen, measured over water at  $+17.3^{\circ}$  C. and 758.2 mm., will be generated by the reaction of 20 g. of zinc with dilute sulphuric acid?

**141.** What volume of "laughing gas," measured at  $+20^{\circ}$  C. and 750 mm., may be made from 12 g. of ammonium nitrate?

**142.** How much phosphorus is required to remove the oxygen from a l. of air?

143. How much alcohol will be needed to use up during combustion 116 g. of oxygen?

144. Find the volume of oxygen needed to burn completely 20 g. of alcohol and the volumes of the products.

145. What volume of phosphine is evolved during the solution of 62 g. of phosphorus in  $\text{Ba}(\text{OH})_2$  solution?

146. Calculate the volume of ammonia obtainable from 126 g. of  $\text{HNO}_3$ .

147. If 5580 cc. of  $\text{HF}$  are passed over heated sodium, how much of each product is obtained?

148. An excess of  $\text{Ag}_2\text{O}$  is thrown into 136 g. of a solution of  $\text{H}_2\text{O}_2$  containing 75% water; what gas is evolved, and what will be its volume at  $-133^\circ \text{C}$ . and 1520 mm.?

149. If 55 g. of  $\text{HgO}$  are heated, what is the volume of the oxygen at 667 mm. and  $+22^\circ \text{C}$ .?

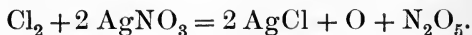
150. To produce 112 l. of hydrogen from steam, how much charcoal must be used?

151.  $\text{MnO}_2$  is treated with 10 l. of  $\text{HCl}$ . Find weight and volume of chlorine produced.

152. What weight of ammonium sulphate would be produced by neutralizing 100 g. of pure sulphuric acid with ammonia?

153. How much carbon dioxide by weight and by volume can be prepared from 275 g. of calcium carbonate?

154. What volume of chlorine at  $+15^\circ \text{C}$ . must be passed over 20 g. of  $\text{AgNO}_3$  to obtain  $\text{N}_2\text{O}_5$ ?



155. What volume of  $\text{H}_2\text{S}$  would be needed to produce 10 g. of  $\text{CuS}$  from a  $\text{CuSO}_4$  solution?

156. Calculate the volume of carbon dioxide, measured at  $0^\circ \text{C}$ . and 760 mm., that can be made from 50 g. of calcium carbonate and an excess of hydrochloric acid.

157. Into what volume of oxygen will 96 g. of ozone break up?

158. If 500 g. of hydrogen are needed, how much steam is required?

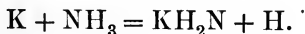
159. If 5 g. of zinc are dissolved in acid, how many cc. of hydrogen are freed when measured at  $+10^\circ \text{C}$ . and 750 mm.?

160. How many cc. of  $\text{HCl}$  solution, containing 240 g. of  $\text{HCl}$  per l., will be required to decompose 2500 g. of  $\text{CaCO}_3$ ?

161. How many l. of (a) hydrogen and (b) carbon monoxide, at  $+10^\circ \text{C}$ . and 750 mm., can be obtained by passing steam over 24 g. red-hot charcoal?

162. If 13 g. of sodium are placed on water, the conditions being  $+11^\circ \text{C}$ . and 700 mm., how many  $\text{m}^3$  of gas are liberated?

163. If 2 g. of potassium are heated in  $\text{NH}_3$ , how much potassium amide and what volume of hydrogen at  $+15^\circ \text{C}$ . are formed?

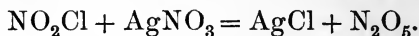


164. What weight of nitric oxide would be needed to unite with the oxygen of the air in a 10 l. flask?

165. If a man exhale one  $\text{m}^3$  of  $\text{CO}_2$  in an hour, at  $+16^\circ \text{C}$ ., how long will it take him to produce 5 Kg. of the gas?

166. When 10 g. of sulphur burn in contact with hydrogen, what volume and weight of  $\text{H}_2\text{S}$  could be produced?

167. If 2 l. of nitrosyl chloride at  $+15^\circ\text{C}$ . are passed over warm lunar caustic, how much  $\text{N}_2\text{O}_5$  is formed?



168. A balloon holds 15,000 l. What weight of  $\text{NH}_4\text{NO}_3$  will give enough gas to fill the balloon at  $+20^\circ\text{C}$ . and 600 mm.?

169. Find weight of copper needed to produce 15 l. of NO at 871 mm. and  $+22^\circ\text{C}$ .

170. If 20 l. of oxygen under 420 mm. pressure will be enough to burn completely 20 g. of phosphorus, at what temperature is it?

171. If 300 cc. of  $\text{NH}_3$  react with chlorine, what volume of nitrogen is obtained at  $-6^\circ\text{C}$ . and 327 mm. pressure?

172. What volume of hydrogen is required by 19 g. of chlorine to produce hydrochloric acid?

173. If 300 cc. of chlorine are obtained from the electrolysis of HCl, what weight and volume of hydrogen are given off, and what weight of HCl is used?

174. If 130 g. of pyrolusite (90.7 % pure) are heated with an excess of HCl, what is the volume of the gas given off?

175. A tank contains 6 m.<sup>3</sup>. How many g. of zinc and acid are needed to fill it with hydrogen at standard conditions?

176. If 1 g. each of K, Li, Na, and Ca are placed in water separately and the hydrogen of each is measured, which metal will give the greatest yield in cc.? Find weight from each.



**177.** Find weight of 17 l. of ethylene. What volume of oxygen would be needed to burn it?

**178.** How many g. and l. of oxygen will be given by 300 g. of  $\text{K}_2\text{Cr}_2\text{O}_7 + \text{H}_2\text{SO}_4$  in excess?

**179.** How many l. of chlorine will be liberated by treating 39 g. of  $\text{KClO}_3$  with sufficient  $\text{HCl}$  solution to decompose it?

**180.** If 98 g. of  $\text{H}_2\text{SO}_4$  react on  $\text{K}_2\text{Cr}_2\text{O}_7$ , what volume of oxygen, measured at  $+12^\circ \text{C}$ . and 799 mm., will be evolved?

**181.** Calculate the weight of  $\text{NH}_4\text{NO}_3$  required to produce 1900 cc. of  $\text{N}_2\text{O}$ , measured at  $+12^\circ \text{C}$ . and 710 mm.

**182.** If 500 g. of marble are treated with  $\text{HCl}$ , how many g. of  $\text{HCl}$  are needed, and what will be the volume of the resulting gas at  $+15^\circ \text{C}$ . and 740 mm.?

**183.** How many l. of muriatic acid will be liberated by treating 585 g. of salt with  $\text{H}_2\text{SO}_4$ ?

**184.** The iodine in 100 volumes of  $\text{HI}$  is liberated in succession by chlorine and oxygen. Find the volume of chlorine and of oxygen used.

**185.** How much  $\text{SnCl}_2$  must be electrolyzed to give chlorine enough to convert 180 g. of antimony into  $\text{SbCl}_3$ ?

**186.** When 100 g. of  $\text{NH}_4\text{NO}_3$  are decomposed, find the volume of  $\text{N}_2\text{O}$  measured at  $+1^\circ \text{C}$ . and 800 mm.

**187.** If 50 g. of  $\text{CO}$  are needed, what volume of  $\text{CO}_2$  should be passed over red-hot coke?

**188.** What volume of  $\text{H}_2\text{S}$ , measured at  $-31^\circ \text{C}$ . and 777 mm., can be obtained from 10 g. of  $\text{FeS}$ ?

189. What volume of chlorine at  $+27^{\circ}\text{C}$ . and 777 mm. will be required to convert 232 g. of  $\text{Bi}_2\text{O}_3$  into  $\text{Bi}_2\text{O}_5$ ?

190. What volume of  $\text{NH}_3$  will 50 g. of lime liberate from an ammonia salt?

191. What volumes and weights of hydrogen and oxygen are contained in 13 l. of water?

192. If 10 g. of graphite burn in oxygen, what is the weight and volume of  $\text{CO}_2$  formed?

193. What weight of salt will yield (a) 17 l. chlorine; (b) 13 g.  $\text{Na}_2\text{SO}_4$ ; (c) 30 g.  $\text{MnSO}_4$ ; (d) 3 l. of water?

194. If 30 cc. of air and 60 cc. of hydrogen are exploded, what is the volume and weight of the residue?

195. If 16 g. of  $\text{HgO}$  are heated, what is the weight of residue; the weight and volume of gas given off?

196. If 100 g. of steam are passed over red-hot iron, what volume of hydrogen at  $+10^{\circ}\text{C}$ . and 742 mm. is formed?

197. What volume of oxygen can be obtained from 20 g. of manganese dioxide by heating it alone?

198. What volume of oxygen at  $+10^{\circ}\text{C}$ . and 743 mm. can be obtained by the decomposition of a l. of sulphuric acid possessing a density of 1.84 at  $0^{\circ}\text{C}$ .?

199. What weight of hydrochloric acid is produced in the manufacture of 100 tons of salt cake? What volume of gas escapes, supposing the manufacturer to condense only 92 % of the quantity evolved?

200. What volume of oxygen at  $0^{\circ}\text{C}$ . and 760 mm. can be theoretically obtained from 1 lb. of bleaching powder?

**201.** If 1 g. of phosphorus is to be converted into the pentachloride, how many l. of chlorine are required?

**202.** How much marble and hydrochloric acid containing 22 % HCl are needed to yield 10 l. of carbon dioxide at  $+15^{\circ}$  C. and 760 mm. barometric pressure?

**203.** Calculate the volume of nitrogen monoxide at  $+15^{\circ}$  C. and 740 mm. produced on heating 30 g. of ammonium nitrate.

**204.** I require 10 l. of carbon monoxide at  $0^{\circ}$  C. and  $760^{\circ}$  mm. pressure. How many g. of (a) oxalic acid; (b) of formic acid; and (c) of potassium ferrocyanide shall I need?

**205.** A gas bag has a capacity of 45 l.; how much manganese dioxide containing 70 % of  $\text{MnO}_2$  is required to fill it with oxygen at  $+15^{\circ}$  C. and 760 mm.?

**206.** How many cc. of oxygen and hydrogen, measured at  $+12^{\circ}$  C. and under a pressure of 762 mm., can be obtained by the electrolysis of 10 g. of water?

**207.** What weight of ammonia and of chlorine is needed to produce a l. of nitrogen?

**208.** If 100 g. of steam are passed over 1000 g. of red-hot iron wire, what volume of hydrogen is evolved, measured at  $+10^{\circ}$  C. and 742 mm., and what weight of iron oxide is produced?

**209.** Find weight of hydrogen needed to unite with 21 g. of oxygen to form water. How much with (a) 20 g.; (b) 76 g.; (c) 300 g.?

**210.** How many g. of mercury and how many l. of chlorine, measured at a temperature of  $+16^{\circ}$  C. when the barometer stands at 770 mm., are consumed in the manufacture of 100 g. of corrosive sublimate?

211. Find the volume of HF from 71 g. of  $\text{CaF}_2$  and enough  $\text{H}_2\text{SO}_4$ .

212. What weight of  $\text{NH}_4\text{OH}$  is needed to produce  $13\frac{1}{2}$  l. of  $\text{NH}_3$ ?

213. How many g. of  $\text{CaCO}_3$  will produce 114 l. of  $\text{CO}_2$ ?

214. How much sodium acetate and caustic soda is needed to yield 300 cc. of  $\text{CH}_4$ ?

215. If 8 g. of methyl alcohol burn in air, what volume of oxygen is used, and what are the weights of the products?

216. What weight and volume of chlorine is produced by treating 300 g. of HCl with enough  $\text{HNO}_3$ ?

217. How many g. of acid calcium carbonate will 200 l. of  $\text{CO}_2$  with water produce from  $\text{CaCO}_3$ ?

218. What volume of nitrogen, measured at  $-1^\circ \text{C}$ . and 800 mm., is given off on heating 84 g. ammonium dichromate?

219. When 2 g. of sulphur are burned in a closed vessel containing 16 l. of air (21 % O), what volumes of oxygen and sulphur dioxide are present after combustion?

220. How much calcium will liberate 56 l. of hydrogen from water?

221. When 83 g. of cobaltic oxide are heated with HCl, what volume of chlorine is evolved?

222. A balloon holds 200 Kg. of hydrogen. How much Zn and HCl are needed? Find volume of hydrogen at  $+90^\circ \text{C}$ . and 760 mm.

223. A room is 6 m.  $\times$  760 cm.  $\times$  896 mm. Find the weight of air in the room.

**224.** A room 30 m.  $\times$  18 m.  $\times$  15 m. is filled with oxygen. What weight of gas does it contain?

**225.** What volume at  $+20^{\circ}\text{C}$ . and under a pressure of two atmospheres will 100 l. of sulphur dioxide, measured at  $0^{\circ}\text{C}$ . and under a pressure of one atmosphere, occupy? What weight of sulphur is necessary to produce this amount of sulphur dioxide?

**226.** When 10 g. of turpentine are burned, what volume of carbon dioxide is formed?

**227.** How many l. of hydrogen are obtained on dissolving 16 g. of magnesium in dilute sulphuric acid?

**228.** How many l. of hydrochloric acid can be made by the use of 575 g. of  $\text{KCl}$ ?

**229.** When 1 g. of  $\text{HgO}$  and 1 g.  $\text{KClO}_3$  and 1 g.  $\text{Pb}(\text{NO}_3)_2$  are each heated separately and the oxygen is measured, calculate the weight and volume in each case.

**230.** How much ozone will 13 g. of oxygen make? What residue and how much will there be?

**231.** How much carborundum will 2 tons of sand make? What volume of  $\text{CO}$  will be produced? ( $\text{SiO}_2 + 3\text{C} = \text{SiC} + 2\text{CO}$ ).

**232.** Find the volume of  $\text{HF}$  which may be produced from 300 g. of  $\text{CaF}_2$  at  $-6^{\circ}\text{C}$ . and 791 mm.

**233.** If 10 l. of carbon monoxide at  $+14^{\circ}\text{C}$ . and 760 mm. are required, what volume of carbon dioxide must be passed over red-hot carbon, and what mass of carbon is used?

**234.** How many l. of hydrogen phosphide can be made by the use of 250 g. of calcium phosphide?

**235.** How many l. of hydrogen arsenide can be made with 640 g. of zinc arsenide?

**236.** How many l. of hydrogen and of oxygen are necessary to produce 10 cc. of liquid water?

**237.** How many g. of chalk are required to yield 15 l. of choke damp?

**238.** How many cc. of chlorine at a temperature of  $+15^{\circ}\text{C}$ . and under a pressure of 770 mm. can be obtained from 150 g. of silver chloride?

**239.** How much cryolite is needed to prepare 100 l. of hydrogen fluoride at  $+100^{\circ}\text{C}$ . and 500 mm.?

**240.** When 250 cc. of carbon dioxide are passed over red-hot carbon, what volume of carbon monoxide will be formed?

**241.** A room is 25 m. long, 15 m. broad, and 10 m. high; how much carbon dioxide will it contain at the rate of 4 volumes in 10,000?

**242.** What weight in g. of sodium acetate is required to yield 10 l. of methane at  $+20^{\circ}\text{C}$ . and 760 mm.?

**243.** A piece of charcoal is burned in  $2\frac{1}{2}$  l. of oxygen; how many l. of carbon dioxide will be formed, and how much will the carbon dioxide weigh?

**244.** If I wish to obtain 1 l. of oxygen by heating mercuric oxide, what weight of the oxide shall I need?

**245.** What volume of chlorine would exactly decompose 25 g. of hydriodic acid?

**246.** What weight of copper and sulphuric acid is needed to yield 3 l. of  $\text{SO}_2$ ?

**247.** What is the weight of 25 l. of carbon dioxide, and what weight of pure baking soda would be required to prepare it?

**248.** Phosphorus is burned in 15 l. of nitrous oxide; how many l. of nitrogen will remain?

**249.** What volume of hydrogen, measured over water at  $+18^{\circ}\text{C}$ . and 746.4 mm., will be liberated by the action of aluminum upon 20 g. of sulphuric acid containing 41.5 %  $\text{H}_2\text{SO}_4$ ?

**250.** An unknown volume of hydrogen sulphide required 110.34 cc. of chlorine for complete decomposition. What was the volume of the hydrogen sulphide?

**251.** What volume of hydrobromic acid at  $+15^{\circ}\text{C}$ . and 770 mm. pressure would be produced by the action of water upon 50 g. of phosphorus tribromide?

**252.** What volume of oxygen would be required for the complete combustion of 120 g. of bisulphide of carbon?

**253.** What volume of oxygen would be required for the combustion of 125 g. of boron?

**254.** If 20 g. of a silicate containing 20 % of silica are heated with fluorspar and strong sulphuric acid, what volume of silicon fluoride will be produced?

**255.** What weight of materials would be required to prepare 10 l. of chlorine?

**256.** How much copper and nitric acid would be required in order to prepare 100 l. of nitric oxide?

**257.** What volume of oxygen at  $+120^{\circ}\text{C}$ . and 743 mm. can be obtained by treating an excess of  $+\text{KMnO}_4$  with a l. of sulphuric acid possessing a density of 1.84 at  $0^{\circ}\text{C}$ .?

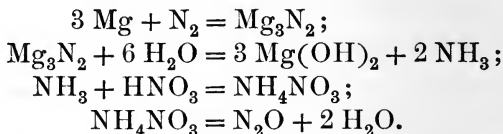
**258.** If 3.5 l. of gaseous hydrofluoric acid at  $+10^{\circ}\text{C}$ . and 765 mm. were obtained by heating fluorspar with oil of vitriol, what weight of fluorspar was used?

**259.** What volume of oxygen would be required to convert 201 g. of phosphorus into (a)  $\text{P}_2\text{O}_3$  and (b)  $\text{P}_2\text{O}_5$ ?

260. If 150 g. of iodine are heated with red phosphorus and water, what volume of hydriodic acid will be produced?

261. What volume of sulphuretted hydrogen is required for the complete precipitation of a solution containing 5 g. of  $\text{As}_2\text{O}_3$ ?

262. If 20 g. of nitrogen are carried through the following series of reactions, calculate the resulting volume of nitrous oxide at standard conditions:



263. What weight and what volume of hydrogen will be evolved by the action of 15 g. of sodium on water? What weight of sodium hydrate will be produced?

264. What volume of sulphuretted hydrogen at  $+13^\circ \text{C}$ . and 700 mm. would be produced by boiling 15 g. of antimony sulphide with strong hydrochloric acid?

265. A piece of pure carbon weighing 12.5 g. is lighted and plunged into a jar containing 16 g. of oxygen; how much carbon, if any, will remain unburned?

266. What volume of hydrogen at  $-5^\circ \text{C}$ . and 770 mm. pressure would be evolved by dissolving 15 g. of pure magnesium in hydrochloric acid?

267. Calculate the volume of carbon dioxide at  $+22^\circ \text{C}$ . and 740 mm. that will be liberated by the action of acid upon 200 g. of calcium carbonate.



**268.** What weight of magnesium will be required for the liberation of 500 cc. of hydrogen at  $+20^{\circ}\text{C}$ . and 740 mm. when acted upon by an acid?

**269.** What weight of aluminum will be required for the liberation of 1420 cc. of hydrogen, measured over water at  $+18^{\circ}\text{C}$ . and 746.4 mm., when acted upon by  $\text{HCl}$ ?

**270.** Calculate the relative weights of sodium chlorate and potassium chlorate necessary to give 20 l. of oxygen at  $-4^{\circ}\text{C}$ . and 770 mm.

**271.** Calculate the relative weights of potassium chlorate and perchlorate ( $\text{KClO}_4$ ) necessary to give 320 l. of oxygen at  $+81^{\circ}\text{C}$ . and 692 mm.

**272.** What volume of chlorine, measured at  $+12^{\circ}\text{C}$ . and 750 mm. pressure, would be produced by heating 50 g. of common salt with sulphuric acid and manganese dioxide?

**273.** The iodine in 600 volumes of hydriodic acid is liberated in succession by chlorine and by oxygen. How many volumes of chlorine and how many volumes of oxygen are required?

**274.** A piece of sodium was completely converted into a chloride by the absorption of 200 cc. of chlorine. What was the weight of the sodium?

**275.** How many l. of sulphuretted hydrogen could be obtained by the action of sulphuric acid upon 329 g. of ferrous sulphide, and what volume of hydrogen would it contain?

**276.** How many l. of oxygen would be required in order to burn completely 53 l. of sulphuretted hydrogen?

**277.** How many l. of sulphur dioxide would be produced by burning sulphur in 158 l. of oxygen?

**278.** What weight and what volume of sulphur dioxide ought to be obtained by heating 250 g. of copper with sulphuric acid?

**279.** If 60 g. of mercuric oxide are heated, what volume of oxygen at  $+91^{\circ}\text{C}$ . and 380 mm. is given off?

**280.** What weight of iron would be required to expel 5 l. of hydrogen from hydrochloric acid?

**281.** A gas tank will hold 321 g. of oxygen. What weight and volume of nitrogen and of carbon dioxide will it hold?

## CHAPTER VIII

### Problems in the Combining Volumes of Gases (Gay-Lussac's Law)

1. If 27 g. of ethylene are completely burned, what is the volume of the products of combustion?

2. If 20 l. of hydrogen and 10 l. of chlorine are exposed to sunlight, what are the volumes of the resulting gases?

3. One l. of marsh gas is burned. Find weight and volumes of oxygen needed, and of gases produced.

4. If 100 cc. of dry ammonia gas are decomposed by electricity, what are the weights and volumes of gases formed?

5. When 16 g. of  $\text{CH}_4$  burn in air, what is the volume of  $\text{CO}_2$  produced and weight of water?

6. If an electric spark is passed through each of the following gaseous mixtures, calculate what volumes result in each case:

- |             |   |                    |
|-------------|---|--------------------|
| 1st mixture | { | 2 volumes oxygen   |
|             |   | 1 volume hydrogen  |
| 2d mixture  | { | 2 volumes hydrogen |
|             |   | 1 volume oxygen    |
| 3d mixture  | { | 1 volume hydrogen  |
|             |   | 2 volumes chlorine |
| 4th mixture | { | 1 volume oxygen    |
|             |   | 2 volumes chlorine |

7. If 1 volume of carbon monoxide is mixed with 1 volume of oxygen and the mixture is exploded in a closed place, what will be the volume of the resulting gas or mixture at the original temperature and pressure?

8. How many l. of oxygen are required in order to burn completely 4 g. of sulphur, and how many l. of sulphur dioxide will be formed?

9. What weight of water will be produced by burning 5 l. of hydrogen?

10. What weight of HCl would result upon burning 1 l. of hydrogen in chlorine?

11. How many cc. of air are necessary to burn a mixture containing 375 cc. of marsh gas and 450 cc. of olefiant gas ( $C_2H_4$ ), and how much carbon dioxide and aqueous vapor are produced?

12. By the combustion of 1 cc. of sulphuric ether having a sp. gr. of 0.72, how many cc. of carbon dioxide and of aqueous vapor are produced, and how much oxygen is consumed?

13. After liberating, by chlorine, the iodine in 265 cc. of hydriodic acid, there were 318 cc. of a mixture of hydrochloric acid and chlorine. What was the volume of each gas in the mixture?

14. How many l. of air (21 % O) ought to be mixed with 100 volumes of "fire damp" to supply material for the complete combustion of this gas during explosion?

15. If 40 g. of ammonia and 40 g. of HBr are brought together, what weight of ammonium bromide results? What is left over, and what is its volume at + 220° F. and 768 mm.?

16. How many l. of air at  $+20^{\circ}\text{C}$ . and 780 mm. are required for the complete combustion of 16 l. of methane; of ethylene; of acetylene; of carbon monoxide; of ammonia; of hydrogen sulphide?

17. If 1000 g. of bromine are to be united with hydrogen, what volume of hydrogen is needed at  $+450^{\circ}\text{C}$ . and 766 mm.? What volume of products results?

18. If 50 l. of hydrogen and 30 l. of chlorine are mixed and exploded, what volume of hydrogen chloride is produced? What gas and how much remains in excess?

19. What volume of hydrochloric acid would result from the complete combination of 50 l. of chlorine with hydrogen, the final temperature and pressure being the same as the initial?

20. What volume of hydrogen would combine with 20 l. of oxygen? How many l. of water vapor would result?

21. How many l. of oxygen will combine with 20 l. of nitric oxide, and what volume of nitrogen peroxide would be formed?

22. What volume of carbon dioxide will result from the combustion of 27.4 l. of carbon monoxide?

23. What volume of oxygen is necessary to completely burn 40 l. of the vapor of benzene, and how many l. of carbon dioxide and water vapor would be formed?

24. In a eudiometer 88 cc. of hydrogen and 132 cc. of chlorine are exploded by a spark; what volume of hydrochloric acid is formed, and what volume of uncombined gas will remain?

## 110 PROGRESSIVE PROBLEMS IN CHEMISTRY

25. What volume of oxygen is required to burn 1 l. of the vapor of alcohol to carbon dioxide and water?

26. What volume of oxygen is required to burn completely 175 cc. of acetylene?

27. If ammonia and chlorine react to form nitrogen and hydrochloric acid, what volume of chlorine is required to react completely with 160 l. of ammonia, and what volumes of nitrogen and hydrochloric acid result?

28. 3 l. of a mixture in equal volumes of  $\text{CH}_4$ ,  $\text{C}_2\text{H}_4$ , and  $\text{CO}$  are burned, the products being  $\text{H}_2\text{O}$  and  $\text{CO}_2$ . How much oxygen is required and how much  $\text{CO}_2$  is formed?

29. If 7 l. of hydrogen are mixed with 8 l. of oxygen and burned so far as possible, what volume of the product (as a vapor) is formed and what is left uncombined?

30. What volumes of gases will be left if 3 l. of  $\text{CH}_4$  and 2 l. of air are caused to unite, so far as possible?

31. What volumetric mixture of acetylene and air would be most dangerously explosive?

32. Show the relative volumes of the five gases present when alcohol vapor burns in air.

33. How many l. of hydrochloric acid and of oxygen can be made by the use of 875 g. of water? How many l. of chlorine are required?

34. How many l. of air are necessary to burn 150 g. of benzol? Composition of air is oxygen 20.96 % and nitrogen 79.04 %.

35. When 30 l. of hydrogen were mixed with 18 l. of oxygen and chemical union was produced, how much aqueous vapor having a temperature of  $+140^\circ\text{C}$ . and

760 mm. was obtained? Which gas remained in excess, and what was its volume at the temperature and pressure given above?

36. How many l. of oxygen would be required to burn 10 l. of  $\text{H}_2\text{S}$ ?

37. How many l. of oxygen will combine with 10 l. of nitric oxide, and what volume of nitrogen peroxide will be formed?

38. If nitrogen and hydrogen could be made to combine completely, what volume of each would be required to form 10 l. of gaseous ammonia?

39. What volume of hydrogen and of oxygen at  $+100^\circ\text{C}$ . would combine to form 1 l. of steam?

40. If 1000 l. of ammonia gas are decomposed, what volume of nitrogen and of hydrogen result if measured at  $-10^\circ\text{C}$ . and 600 mm.?

41. If 30 cc. of hydrogen are mixed with 40 cc. of air that contains 20 % of oxygen, and the mixture is ignited, what gases remain after explosion and what is the volume of each?

42. A mixture of 10 cc. of hydrogen and 10 cc. of chlorine, exploded by an electric spark, yields 20 cc. of hydrogen chloride. Show how this indicates that the molecule of hydrogen consists of at least two atoms.

43. If 2 volumes of ethylene weighing 28 g. are burned in air, what volumes of nitrogen and of other gases result?

44. After 72 cc. of  $\text{NH}_3$  are decomposed by electricity, 100 cc. of oxygen are introduced and the mixture is exploded; what gases remain and how much of each?

45. One Kg. of carbon disulphide is burned in oxygen. What weight of oxygen is needed, and what is the volume of each of the products formed at  $+20^{\circ}\text{C}$ . and 760 mm.?

46. When 150 cc. of oxygen are mixed with 400 cc. of hydrogen and the mixture is exploded, what volume of steam is produced? Which gas, and how much of it, remains uncombined?

47. If 50 cc. of hydrogen are exploded with 75 cc. of oxygen, what is the total volume of the gases after the explosion, measured at  $+150^{\circ}\text{C}$ . and 760 mm. pressure?

48. When 40 l. of CO are burned, what is the volume of  $\text{CO}_2$  produced?

49. What volumes of the components would yield 100 g. of nitrogen tetroxide?

50. If 500 cc. of oxygen are exploded with 250 cc. of hydrogen, what gas, if any, will remain and how much of it?

51. How much oxygen will be required for the complete combustion of 10 g. of stibine and arsine, respectively?

52. How many l. of oxygen are contained in 3 l. of nitrogen tetroxide?

53. If 20 g. of  $\text{MnO}_2$  are boiled with an excess of hydrochloric acid until all the  $\text{MnO}_2$  is decomposed, and the resultant chlorine is united with hydrogen, what volume of  $\text{H}_2$  is needed, and what volume of HCl results if both are measured at  $+45^{\circ}\text{C}$ . and 746 mm.?

54. What volume of oxygen is required for the combustion of 575 cc. of  $\text{AsH}_3$ ?

55. How many cc. of hydrogen and nitrogen are contained in a l. of ammonia gas?



56. If 100 volumes of air containing 21 volumes of oxygen are mixed with 70 volumes of hydrogen, and an electric spark is passed through the mixture, what will be the volume of the gas remaining and of what will it consist?

57. If 50 cc. of hydrogen are exploded with 45 cc. of oxygen, what is the total volume of the gases after the explosion, measured at  $+150^{\circ}\text{C}$ . and 760 mm. pressure?

58. How many cc. of hydrogen and nitrogen are contained in 1 m.<sup>3</sup> of ammonia gas?

59. How many l. of hydrogen can be obtained from 6 l. of HCl?

60. One ft.<sup>3</sup> of hydriodic acid is decomposed by an excess of bromine. How many ft.<sup>3</sup> of hydrobromic acid are formed?

61. What volume of oxygen is required for the complete combustion of 101 g. of  $\text{SbH}_3$ ?

62. If 50 cc. of air are mixed with 25 cc. of hydrogen and exploded in a eudiometer, what volume will the remaining gas occupy and of what will it consist?

63. What weight of oxygen is required for the complete combustion of 24 l. of phosphine, measured at  $+15^{\circ}\text{C}$ . and 740 mm. pressure?

64. An unknown volume of hydrogen sulphide required 157 cc. of oxygen for complete decomposition. What was the volume of the hydrogen sulphide?

65. A mixture of 300 cc. of methane and 150 cc. of oxygen was exploded. What was the volume of the product after the removal of aqueous vapor (by absorption), temperature being  $+100^{\circ}\text{C}$ . and pressure 760 mm. constant throughout?

66. A mixture of 250 cc. of carbon monoxide and 120 cc. of oxygen was exploded. Calculate the volume of gaseous product.

67. A mixture of 420 cc. of hydrogen and 180 cc. of oxygen was exploded. What was the volume of product after the removal of aqueous vapor (by absorption with phosphorus pentoxide), temperature being  $+100^{\circ}$  C. and pressure of 760 mm.?

68. If 17 l. of  $\text{NH}_3$  are decomposed, how many l. will there be of resultant gases?

69. A mixture of 200 cc. of carbon monoxide and 300 cc. of oxygen was exploded over mercury. Calculate the volume of product, at  $+27^{\circ}$  C. and pressure of 740 mm. constant throughout.

70. A mixture of oxygen and hydrogen measuring 250 cc. was exploded. The volume of product measured 76.47 cc., at  $+17^{\circ}$  C. and pressure of 754.4 mm. Calculate the volumes of hydrogen and oxygen.

71. A mixture of 320 cc. of carbon monoxide and 1800 cc. of oxygen was exploded. Calculate the volume of gaseous product after the removal of the carbon dioxide (absorption by lime).

72. A mixture of 80 cc. of methane and 200 cc. of oxygen was exploded over mercury. Calculate the volume of product, at temperature of  $+20^{\circ}$  C. and barometric pressure of 757.4 mm. constant.

73. A mixture of 490 cc. of hydrogen and 1300 cc. of oxygen was exploded. Calculate the volume of product, at temperature of  $+25^{\circ}$  C. and pressure 753.6 mm. constant.

**74.** When 250 cc. of dry air were mixed with 150 cc. of hydrogen and exploded, the volume of product was 350 cc. Calculate the percentage of oxygen in the sample of air. Temperature of  $+100^{\circ}\text{C}$ . and atmospheric pressure remained constant.

**75.** A mixture of hydrogen sulphide with an excess of oxygen measured 350 cc. at  $+160^{\circ}\text{C}$ . and 750 mm. pressure. After explosion (with complete combustion), the volume of dry gaseous product read 260 cc. at these same conditions. Calculate the volume of hydrogen sulphide in the mixture.

**76.** Find the proportions by weight and by volume in which ethane will combine with oxygen.

**77.** A volume of nitric oxide, measuring 400 cc., was required for the combustion of a definite weight of phosphorus. What volume of nitrogen remained free?

**78.** What volume of water gas is theoretically possible from the action of 1 l. of steam upon heated coke?

**79.** In the decomposition of methane by chlorine, what volume of hydrogen chloride corresponds to 1 volume of methane?

**80.** A mixture of 400 cc. of methane and 1000 cc. of chlorine was exploded. Calculate the volume of gaseous product.

**81.** How many l. of air are required for the complete combustion of 10 l. of (a) marsh gas; (b) olefiant gas; (c) acetylene?

**82.** If 5 l. of chlorine are mixed with 5 l. of carbon monoxide, what volume of phosgene gas is produced, and how much hydrochloric acid and carbon dioxide would be produced by the decomposition of this gas with water?

83. If 5 l. of carbon monoxide are burned, what volume of oxygen will be used, and what volume of carbon dioxide will be formed?

84. If an electric spark is passed through a mixture of 5 volumes of carbon monoxide and 3 volumes of oxygen, what diminution in bulk will be observed?

85. If 50 cc. of carbon monoxide are mixed with 20 cc. of oxygen and exploded, and the resulting mixture is then shaken up with sodium hydrate, what volume of gas will remain and what gas will it be?

86. Carbon is burned in 220 l. of oxygen; what volume of carbon dioxide will be formed?

87. If 50 cc. of nitrous oxide are decomposed into nitrogen and oxygen, how many cc. of each will be formed?

88. A mixture of acetylene with an excess of oxygen measured 350 cc. at  $+25^{\circ}\text{C}$ . and 745 mm. pressure. After explosion the volume of dry gaseous product read 275 cc. under the same conditions. Calculate the volume of acetylene in the mixture.

89. A mixture of acetylene with an excess of oxygen measured 240 cc. at  $+24^{\circ}\text{C}$ . and 752.4 mm. pressure. After explosion the volume of product read 221.8 cc. at  $+28^{\circ}\text{C}$ . and 750.1 mm. pressure. Calculate the volume of acetylene in the mixture.

90. If 600 volumes of carbon monoxide are mixed with 600 volumes of oxygen, an electric spark is passed through the mixture, and then a solution of caustic potash is added, what volume of gas will be absorbed and of what will the residue, if there is any, consist?

91. How many volumes of oxygen are required for the complete combustion of 1 l. of each of the following: (a) CO; (b) CH<sub>4</sub>; (c) C<sub>2</sub>H<sub>4</sub>; (d) C<sub>2</sub>H<sub>2</sub>; (e) H<sub>2</sub>S; (f) H?

92. If 500 cc. of hydrogen at + 39° C. are exploded with 500 cc. of oxygen under a pressure of 332.5 mm., what volume of which gas is left?

93. How many l. of oxygen will be required to burn 50 l. of C<sub>2</sub>H<sub>4</sub> and how many of CO<sub>2</sub> will form?

94. If 10 ft.<sup>3</sup> of H<sub>2</sub>S are burned, what volume of each product will be formed?

95. I have 5500 cc. of CO<sub>2</sub> formed by the combustion of CO in air. How much air was required and how much CO?

96. State the volume of the products resulting from the combustion of 2.5 l. of carbon disulphide gas.

97. What volume of products results from the decomposition of 100 l. of ammonia?

98. One million molecules of hydrogen will unite with how many molecules of oxygen to form how many molecules of water? What will be the relative weights of hydrogen and water?

99. A mixture of 10 cc. of chlorine and 10 cc. of hydrogen, exploded by an electric spark, yields 20 cc. of hydrogen chloride. Show how this indicates that the molecule of hydrogen consists of at least 2 atoms.

## CHAPTER IX

### Calculation of Formulas

1. A compound has the following percentage composition: carbon, 37.61%; hydrogen, 12.53%; oxygen, 49.86%. One l. of its vapor weighs 1.4339 g., What is its formula?

2. A gas has the following composition: carbon, 27.39%; oxygen, 72.60%. Its density (air) is 1.52. What is its formula?

3. What is the simplest formula of a substance which consists of oxygen, 88.83%, and hydrogen, 11.11%?

4. Calculate the simplest formula of mercuric oxide, which contains 92.59% of mercury and 7.41% of oxygen.

5. What is the simplest formula of a substance consisting of calcium, 29.49%; sulphur, 23.59%; and oxygen, 46.92%?

6. The percentage composition of a mineral is found to be: calcium, 40.12%; carbon, 12.04%; and oxygen, 47.84%. What is its simplest formula?

7. Acetic acid consists of carbon, 40%; hydrogen, 6.67%; and oxygen, 53.33%. Its vapor density is 30. What is its molecular formula?

8. What is the molecular formula of the gas having the composition: nitrogen, 30.43%; oxygen, 69.57%? The weight of 1 l. is 2.061 g.

9. What is the molecular formula of the gas having the density 197 and the composition: iodine, 96.70 %; carbon, 3.05 %; hydrogen, 0.25 %?

10. In 100 parts of a compound of manganese and oxygen there are 63.22 parts of manganese and 36.78 parts of oxygen. What is the simplest formula possible?

11. Calculate the formulas of the following:

Ba = 58.80	K = 31.91	Ca = 40.00	Ag = 75.27
S = 13.75	Cl = 28.94	C = 12.00	Cl = 24.73
O = 27.45	O = 39.15	O = 48.00	

12.

K = 38.68	Mg = 21.65	K = 16.00	Na = 18.54
N = 13.89	P = 27.92	Pt = 40.41	S = 25.84
O = 47.43	O = 50.43	Cl = 43.59	H = 0.81
			O = 25.79
			H <sub>2</sub> O = 29.02

13.

Na = 18.54	CaO = 9.20	Fe = 72.41
S = 25.84	Al <sub>2</sub> O <sub>3</sub> = 16.85	O = 27.59
H = 4.03	SiO <sub>2</sub> = 59.29	Mn = 71.69
O = 51.59	H <sub>2</sub> O = 14.66	O = 28.31

14.

Cu = 34.46	CaO = 43.45	Ag = 53.15	Lithia = 6.43
Fe = 30.59	Al <sub>2</sub> O <sub>3</sub> = 17.68	Cu = 31.08	Alumina = 29.26
S = 34.95	SiO <sub>2</sub> = 38.87	S = 15.77	Silica = 64.31

15.

Pb = 76.36	C = 21.03	C = 52.17	K = 42.41
P = 6.86	H = 2.63	H = 13.04	Fe = 15.22
Cl = 2.62	K = 34.27	O = 34.79	C = 19.56
O = 14.16	O = 14.03		N = 22.81
	S = 28.04		

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16.

C = 90.57	C = 89.55	C = 79.73	Si = 19.50
H = 9.43	H = 10.45	H = 6.32	C = 66.62
		N = 13.95	H = 13.88

17.

C = 75.46	H = 6.59	N = 8.38	O = 9.57
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18. Find the formula of that nitrate which gave, by analysis, 62.45 % lead, 8.68 % nitrogen, and 28.85 % oxygen.

19. Derive the formula of that substance which gave, by analysis, 52.02 % carbon, 13.20 % hydrogen, and 34.68 % oxygen.

20. What is the formula of that acetate which gave, by analysis, 63.61 % lead, 14.62 % carbon, 1.98 % hydrogen, and 19.79 % oxygen?

21. An oxide of iron gave, by analysis, 69.80 % iron; what is the formula?

22. An oxide of barium gave, by analysis, 81 % barium; what is the formula?

23. The vapor density of a gas is 13.91. The analysis gives the following composition: C = 85.62 and H = 14.38. What is the formula? Find the weight of 1 l.

24. Derive the formula of the oxide produced when 6.87 g. of barium unite with 1.6 g. of oxygen.

25. Find the formula of the oxide formed in the combustion of 2.61 g. of aluminum with oxygen to a final weight of 5.01 g.

26. What is the formula of the oxide produced by the combustion of 43.45 g. of lead with 4.48 g. of oxygen?



27. Derive the formula of the oxide produced by the burning of 2.5 g. of phosphorus in oxygen to a final weight of 5.7 g.

28. Calculate the formulas of:

(a)	(b)
N = 22.05	SiO <sub>2</sub> = 23.53
C = 14.18	CaO = 1.90
O = 56.68	Al <sub>2</sub> O <sub>3</sub> = 37.72
H = 7.09	Water = 36.85

29. What will be the formula of a hydrocarbon that contains twice as many hydrogen atoms as carbon, and the vapor of which has a density of 1.947?

30. Find the simplest formula for acid potassic carbonate, its percentage composition being: hydrogen, 1.00; potassium, 39.06; carbon, 11.99; oxygen, 47.95.

31. In 100 parts of crystallized ferrous sulphate there are 20.15 parts of iron, 11.51 parts of sulphur, 23.02 parts of oxygen, and 45.32 parts of water; what is its simplest formula?

32. What is the simplest formula of morphia, its percentage composition being: carbon, 71.58; hydrogen, 6.66; nitrogen, 4.91; oxygen, 16.85?

33. Derive the formula of crystallized sodium sulphate, 8.16 g. of which lost 4.51 g. of water upon dehydration.

34. Find the formula of crystallized copper sulphate, 7.84 g. of which lost 2.79 g. of water upon heating.

35. Calculate the formula of crystallized aluminum sulphate, 9.54 g. of which lost 4.61 g. of water upon heating.

36. Work out the formula of aluminum hydroxide, 4.75 g. of which lost 1.64 g. of water and left a residue of  $\text{Al}_2\text{O}_3$ .

Deduce the formulas of the following substances :

37. Magnesium, 9.76; sulphur, 13.01; oxygen, 26.01; water, 51.22.

38. Zinc, 22.70; sulphur, 11.15; oxygen, 22.28; water, 43.87.

39. Sodium, 32.79; aluminum, 13.02; fluorine, 54.19.

40. Aluminum, 16; sulphur, 28; oxygen, 56.

41. Copper, 57.46; carbon, 5.43; hydrogen, 0.91; oxygen, 36.20.

42. Hydrogen, 3.18; oxygen, 33.88; nitrogen, 14.84; sulphur, 16.95; nickel, 31.15.

43. Carbon, 19.04; hydrogen, 4.76; sulphur, 25.40; oxygen, 50.80.

44. Carbon, 46.66; hydrogen, 4.26; nitrogen, 5.20; oxygen, 5.92; platinum, 18.26; chlorine, 19.70.

45. Calculate the formula of the nitrate, 19.7 g. of which were prepared from 10.4 g. of bismuth.

46. Find the formula of that chlorate, 4.165 g. of which lost 1.3 g. of oxygen upon heating and gave a residue of barium chloride.

47. What is the formula of mercuric cyanide, 5.4 g. of which lost 1.1 g. of cyanogen upon heating?

48. Derive the formula of the double salt of ammonium sulphate and copper sulphate, 4.12 g. of which lost 1.81 g. of ammonium sulphate upon heating.

49. The vapor density of steam is 9. The percentage composition of water is: hydrogen, 11.11; oxygen, 88.89. What is the formula of water?

50. The vapor density of alcohol vapor is 23. In 100 parts there are 52.18 parts of carbon, 13.04 parts of hydrogen, and 34.78 parts of oxygen. What is the formula of alcohol?

51. The vapor density of the vapor of ethylene chloride is 49.5, and its percentage composition is: carbon, 24.24; hydrogen, 4.04; chlorine, 71.72. What is its formula?

52. The vapor density of a certain gas is 13.91, or the weight of a l. of this gas at  $0^{\circ}$  C. and 760 mm. pressure is 1.26 g. (Use only one of these weight relations.) The analysis of this gas gave the following percentages: carbon, 85.62; hydrogen, 14.38. What is the formula?

53. Analysis of a compound gave: lead, 68.30%; sulphur, 10.55%; oxygen, 21.15%. Calculate the empirical formula.

54. Calculate the empirical formulas from the following analytical results: potassium, 52.45%; chlorine, 47.55%. Arsenic, 41.32%; chlorine, 58.66%. Sodium, 32.43%; hydrogen, 0.71%; phosphorus, 21.82%; oxygen, 45.04%. Potassium, 35.56%; iron, 17.00%; cyanogen, 47.44%. Magnesium, 21.82%; phosphorus, 27.86%; oxygen, 50.32%.

55. Aldehyde has the following composition: C, 54.67%; H, 9.11%; and O, 36.22%. The density (air) of its vapor is 1.526. What is its formula?

56. Butyric acid has the same percentage composition as an aldehyde, but the density (air) of its vapor is 3.052. What is its formula?

57. Analysis of a compound gives 26.67% C, 2.22% H, and 71.11% O; what is its simplest formula? If that is the correct one, what should be the vapor density of the gas?

58. A compound consists of 5.88 % H and 94.12 % O ; find the smallest formula that can apply to it.

59. An ore of iron analyzes 70 % Fe and 30 % O : what formula should it have ?

60. Zinc is obtained from its sulphide, a specimen of which contains 67.01 % Zn and 32.99 % S. Ascertain the formula of zinc sulphide.

61. Find the formula of a hydrocarbon that contains an equal number of hydrogen and carbon atoms, and the vapor of which has a density (air) of 0.9.

62. Formic acid has the composition: C, 26.21 % ; O, 69.43 % ; and H, 4.36 %. The density (air) of its vapor is the same as that of alcohol. Find the formula.

63. Find the formulas of the following two substances:

(a)	(b)
Bi = 42.99	K = 8.24
O = 29.74	Al = 5.69
N = 8.67	S = 13.50
Water = 18.60	O = 27.01
	Water = 45.56

64. Oxalic acid consists of C, 26.79 % ; H, 2.23 % ; and O, 70.98 %. Find the formula.

65. Alcohol is C, 52.28 ; O, 34.64 ; and H, 13.08. Calculate the formula.

66. Deduce the formulas of the following :

(a)	(b)
Fe = 20.15	K = 7.77
S = 11.51	Mn = 10.95
O = 24.02	S = 12.75
Water = 44.32	O = 25.48
	Water = 43.05

67. Red lead consists of Pb, 90.65 %; and O, 9.35 %. What is the formula?

68. The sp.gr. of mercurous chloride is 7. It contains 84.92 % of Hg and 15.08 % of chlorine. To what formula would this correspond?

69. Calculate the formula of the following:

Na = 14.41 Sb = 25.05 S = 26.72 Water = 33.82

70. Calculate the formulas from the following per cents: calcium, 38.72; phosphorus, 20.00; oxygen, 41.28.

71. Potassium, 28.73; hydrogen, 0.73; sulphur, 23.52; oxygen, 47.02.

72. Potassium, 45.95; nitrogen, 16.45; oxygen, 37.60.

73. Aluminum, 16; sulphur, 28; oxygen, 56.

74. Carbon, 85.71; hydrogen, 14.29.

75. Carbon, 92.3; hydrogen, 7.7.

76. One volume of a gaseous hydrocarbon at +100° C. yields on combustion double its volume of CO<sub>2</sub> and 3 times its volume of steam at the same temperature. Find the formula of the gas.

77. A compound has the following composition: phosphorus, 20.22 %; oxygen, 10.43 %; chlorine, 69.35 %. The density (air) of its vapor is 5.295. What is its formula?

78. If an iron ammonium sulphate contains  $\frac{1}{7}$  of its weight in iron, find the formula.

79. A compound has the following composition: phosphorus, 22.58 %; chlorine, 77.42 %. One l. of the vapor weighs 6.13 g. Calculate the formula.

80. Calculate the formulas of the substances possessing the following percentage compositions:

Magnesium = 25.57 Sodium = 32.43 Potassium = 26.585.

Chlorine = 74.43 Sulphur = 22.55 Chromium = 35.390

Oxygen = 45.02 Oxygen = 38.025

81. Find the formula when Zn = 22.67; S = 11.15; O = 22.29; and water = 43.89.

82. Calculate the formula when Zn = 54.14; Si = 11.67; O = 26.67; and water = 7.52.

83. Assign formulas to the following:

(a)

(b)

CO = 22.74

$\text{Al}_2\text{O}_3$  = 16.86

N = 26.96

CaO = 9.20

Cl = 41.05

$\text{SiO}_2$  = 59.28

H = 5.78

Water = 14.66

Water = 3.47

84. Calculate the formulas from the following per cents: carbon, 19.04; hydrogen, 4.76; sulphur, 25.40; oxygen, 50.80.

85. Carbon, 74.07; hydrogen, 8.64; nitrogen, 17.29.

86. Carbon, 46.66; hydrogen, 4.26; nitrogen, 5.20; oxygen, 5.92; platinum, 18.26; chlorine, 19.70.

87. Lime, 28.4; magnesia, 12.3; iron monoxide, 12.3; manganese monoxide, 1.9; carbon dioxide, 44.4.

88. A mineral gave the following numbers on analysis:  $\text{SiO}_2$ , 46.96;  $\text{MgO}$ , 31.26;  $\text{H}_2\text{O}$ , 21.22. Calculate its formula.

89. A specimen of cobalt bloom was found to have the following composition:  $\text{As}_2\text{O}_5$ , 38.43;  $\text{CoO}$ , 36.52;  $\text{FeO}$ , 1.01;  $\text{H}_2\text{O}$ , 24.14. Determine its formula.

90. One hundred cc. of ammonia gas are completely decomposed by a series of electric sparks, yielding 200 cc. of mixed hydrogen and nitrogen. An excess of oxygen is next added, when the volume of mixed gases is found to amount to 290 cc. The mixture is now exploded, when 65 cc. of gas remain. Show from these data that the formula for ammonia is  $\text{NH}_3$ .

91.  $\text{Ca} = 40$ ;  $\text{C} = 12$ ;  $\text{O} = 48$ . Calculate the simplest formula. Find the percentage composition of C in this formula to see if your answer is correct.

92. Calculate the molecular formula of a substance having the following composition: carbon, 74.1%; hydrogen, 8.6%; nitrogen, 17.3%. The vapor density is 81.

93.  $\text{C} = 10.04\%$ ;  $\text{H} = 0.83\%$ ;  $\text{Cl} = 89.13\%$ ; and the vapor density is 59.75. Find the formula.

94. On analysis, 18 g. of a compound of iron and sulphur yielded 8.4 g. of iron and 9.6 g. of sulphur; what is its simplest formula?

95. On analysis, 48 g. of a compound yielded 37.21 g. of lead, 2.16 g. of carbon, and 8.63 g. of oxygen; what is its simplest formula?

96. What is the simplest formula of a substance, 27 g. of which, on analysis, yielded 2.64 g. of magnesium, 3.51 g. of sulphur, 7.02 g. of oxygen, and 13.83 g. of water?

97. A compound of arsenic and oxygen is composed of 75% As, 24% O; what is its smallest formula? Its vapor density being 198, what should be its true formula?

98. A compound of hydrogen and carbon has 92.3% C and 7.7% H. Find its smallest formula. The density being 13, what is the proper formula?

99. An analysis of a salt gave the following percentage numbers: S, 22.53; Na, 32.39; O, 45.08. What is its empirical formula?

100. A salt on analysis gives the following percentage numbers: N, 9.09; O, 20.77; Ag, 70.13. Calculate the simplest formula for this body.

101. Calculate the formula for a body which has the following percentage composition: oxygen, 38.1; hydrogen, 0.8; phosphorus, 24.6; sodium, 36.5.

102. Calculate the formula of a body which has the following percentage composition: magnesium, 3.98; calcium, 13.28; potassium, 12.99; sulphuric acid ( $\text{SO}_4$ ), 63.77; water, 5.98.

103. Find the formula of the following: O, 48%; S, 24%; and Fe, 28%.

104. A substance contains carbon, 20%; oxygen, 26.6%; and sulphur, 53.3%. Find its formula.

105. Find the formulas of the following minerals:

(a)	(b)
$\text{SiO}_2 = 65.69$	$\text{N}_2\text{O} = 4.21$
$\text{Al}_2\text{O}_3 = 17.97$	$\text{CaO} = 12.93$
$\text{CaO} = 1.34$	$\text{Al}_2\text{O}_3 = 30.68$
$\text{N}_2\text{O} = 1.01$	$\text{SiO}_2 = 39.99$
$\text{K}_2\text{O} = 13.99$	$\text{H}_2\text{O} = 12.19$

106. Calculate the formulas:

(a)	(b)
$\text{Al}_2\text{O}_3 = 58.66$	$\text{SiO}_2 = 47.24$
$\text{SiO}_2 = 34.20$	$\text{MnO}_2 = 31.50$
$\text{F} = 7.14$	$\text{Water} = 21.26$



## CHAPTER X

### Atomic and Molecular Weight Calculations

1. Ten l. of a gas weigh 17.92 g.; find its molecular weight.

2. The sp. gr. of hydrogen iodide is 4.4; calculate its molecular weight.

3. Find the molecular weight of the gas of which 20 g. occupy 9.9 l. under 1.5 atmospheres pressure at  $+17^{\circ}\text{C}$ .

4. One hundred g. of lead form 146.45 g. of lead sulphate; find the molecular weight of sulphuric acid.

5. The vapor of a compound is found to be thirty-nine times as heavy as hydrogen at the same temperature and pressure. What is the molecular weight of the compound?

6. A l. of nitrous oxide weighs 1.97 g.; find its molecular weight.

7. Find the molecular weight of the gas the density of which is 1.524.

8. A l. of ammonia, under standard conditions, weighs 0.76 g.; find its molecular weight.

9. A l. of nitrous oxide, under standard conditions, weighs 1.97 g.; find its molecular weight.

10. A l. of cyanogen, under standard conditions, weighs 2.33 g.; find its molecular weight.

11. A l. of ethane, under standard conditions, weighs 1.34 g.; find its molecular weight.

12. Find the molecular weight of the gas the density of which is 1.108.

13. A l. of arsine weighs 3.49 g. under standard conditions; find its molecular weight.

14. Find the molecular weight of the gas the density of which is 0.623.

15. Calculate the molecular weights of the following gases:

one l. of ethane weighs 1.34 g.;

one l. of hydrogen sulphide weighs 1.52 g.;

one l. of nitric oxide weighs 1.34 g.;

one l. of phosphine weighs 1.52 g.;

one l. of carbonyl chloride weighs 4.42 g.;

one l. of  $\text{SiF}_4$  weighs 4.68 g.;

one l. of butane weighs 2.59 g.

16. The weight of 3840 cc. of a certain vapor, at standard conditions, is 24 g.; what is the molecular weight of the substance?

17. If 3180 cc. of a gas, measured at  $+24^\circ \text{C}$ . and 750.2 mm. pressure, weighed 6 g., what is the molecular weight?

18. The vapor density of a gas is 44; find its molecular weight, sp. gr., and the weight of 1 l.

19. Calculate the molecular weights of the following gases:

the density (referred to air) of ammonia is 0.59;

the density (referred to air) of HF is 0.69;

the density (referred to air) of methyl alcohol is 1.11;

the density (referred to air) of mercury vapor is 6.91;

the density (referred to air) of HI is 4.42.

20. Find the molecular weights of the following bodies: (air = 1)

cadmium at  $+940^{\circ}\text{C.}$ , relative density = 3.94;

phosphorus at  $+500^{\circ}\text{C.}$ , relative density = 4.35;

mercury at  $+446^{\circ}\text{C.}$ , relative density = 6.98.

21. Determine the molecular weights of the following gases from the data annexed: nitrogen; 2 l. weigh 2.51 g.

22. Carbon monoxide; 1500 cc. weigh 1.88 g.

23. Carbon dioxide; 500 cc. weigh 0.98 g.

24. One l. of  $\text{SO}_2$  weighs 2.86 g.; what is its molecular weight?

25. The weight of  $1\frac{1}{2}$  l. of CO is 1.88 g.; calculate the molecular weight.

26. What is the molecular weight of marsh gas, 3 l. of which weigh 2.15 g.?

27. Sulphur dioxide is 2.22 times as heavy as air; find its density and molecular weight.

28. If 30 g. of a gas occupy 52.7 l. under 0.5 atmospheric pressure at  $+27^{\circ}\text{C.}$ , what is the molecular weight of the gas?

29. A quantity of gas measuring 5.4 l., when the temperature is  $+15^{\circ}\text{C.}$  and pressure 740 mm., weighs 7.6 g.; what is its molecular weight?

30. The vapor density of a gas was 31.17 when its temperature was  $+11^{\circ}\text{C.}$  and under a pressure of 750 mm.; what is its molecular weight?

31. Calculate the molecular weights of the following gases from their vapor densities: (a) chlorine, 35.5; (b) hydrochloric acid, 18.25; (c) ammonia, 8.5; (d) nitrogen, 14; (e) steam, 9.

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32. Berzelius found that 4.20775 parts of  $\text{MnCl}_2$  yielded 9.575 parts of  $\text{AgCl}$ ; what is the atomic weight of silver?

33. By analysis we find that for every 100 parts of silver bromide there are 57.44 parts of Ag and 42.56 parts of Br. The atomic weight of  $\text{Br} = 79.8$ . What is the atomic weight of silver?

34. We find from analysis that barium chloride contains 65.86 % of Ba and 34.14 % of Cl. There are no compounds of Ba the vapor density of which has been determined. The specific heat of Ba being unknown, how would you determine the atomic weight of Ba?

35. Marignac found that 3.8844 g.  $\text{NaCl}$  were required for the precipitation of 11.308 g. of  $\text{AgNO}_3$ ; find atomic weight of nitrogen.

36. By heating 15 g. of pure silver in a stream of chlorine, 19.9306 g. of silver chloride are produced. The weight of the atoms of silver in a molecule of silver chloride is 108. What is the molecular weight of silver chloride and the number of atoms of chloride in a molecule?

37. If 3.17 g. of iron form 4.53 g. of  $\text{Fe}_2\text{O}_3$ , what is the atomic weight of iron?

38. If 8019 cc. of a gas, measured over water at  $+20^\circ \text{C}$ . and 742.4 mm. pressure, weighed 14 g. when deprived of aqueous vapor, what is the molecular weight?

39. If 5647 cc. of a gas, measured over water at  $+24^\circ \text{C}$ . and 754.2 mm. pressure, weighed 6.254 g. when deprived of aqueous vapor, what is its molecular weight?

40. A compound of phosphorus, oxygen, and chlorine contained 20.19% of phosphorus, 10.43% of oxygen, and 69.38% of chlorine. The vapor density of the compound as gas = 77.95 and the specific heat of phosphorus = 0.202. Find the molecular formula of the compound and the atomic weight of phosphorus.

41. The sp. gr. of phosphorus trichloride is 4.88; what is its molecular weight?

42. Sodium chloride contains 39.32% of sodium and its molecular weight is 58.5. What is the atomic weight of sodium, on the supposition that there is but 1 atom of sodium in the molecule of salt?

43. Berzelius obtained 17.554 g. of PbO from 16.2956 g. of lead; find the atomic weight of lead.

44. CuO, when heated in hydrogen, lost 59.80 g. of oxygen and formed 67.3 g. of water. If  $O = 16$ , what is the atomic weight of hydrogen?

45. Stas found that 91.46 g. of metallic silver, when heated in a stream of chlorine, yielded 121.4993 g. of pure silver chloride. Calculate from this the atomic weight of chlorine.

46. Stas found, after adding 7.25682 g. of potassium chloride to 10.51995 g. of silver dissolved in nitric acid, that 0.0194 g. of silver remained in solution. Calculate from these data the atomic weight of potassium.

47. Erdmann and Marchand obtained 109.6308 g. of mercury from 118.3938 g. of the red oxide. Calculate the atomic weight of mercury.

48. If 0.3697 g. of aluminum liberated 0.04106 g. of hydrogen on being dissolved in a strong solution of sodium hydrate, what is the atomic weight of aluminum?

49. Marignac found that 5 g. of strontium chloride, containing 6 molecules of water of hydration, yielded 3.442 g. of strontium sulphate. Calculate the equivalent of strontium.

50. Pure carbon monoxide was passed over red-hot copper oxide; the residual metal and the carbon dioxide formed were weighed; 24.360 g. of oxygen were lost and 67.003 g. of carbon dioxide were obtained. From this calculate the atomic weight of carbon.

51. One g. of an element is found to combine with oxygen so as to form 2.9 g. of oxide; calculate its equivalent.

52. If 0.254 g. of a metal, when dissolved in hydrochloric acid, liberated 116 cc. of hydrogen, measured at  $+15^{\circ}$  C. and 725 mm., what is the equivalent of the metal?

53. Phosphine contains 91.17 % of phosphorus and 8.83 % of hydrogen; find the equivalent of phosphorus.

54. Three oxides of nitrogen contain, respectively, 63.63 %, 46.66 %, and 36.84 % of nitrogen; calculate the equivalent of nitrogen in each of them.

55. A bromide of antimony contains 66.66 % of bromine. If  $\text{Br} = 80$ , calculate the equivalent of antimony.

56. A 1 % sugar solution gives an osmotic pressure of 516 mm. at  $+15^{\circ}$  C. What is the molecular weight of sugar? Assume that the sp. gr. of the solution is 1.

57. The specific heat of an element is  $\frac{1}{10}$ ; and its atomic weight is a multiple of 14. Find the atomic weight of the element.

58. If 200 parts of  $\text{BaCl}_2$  give 224.2 of  $\text{BaSO}_4$ , what is the atomic weight of barium?

59. The equivalent of lead is found to be 103.5 and that of platinum 48.6; determine the probable atomic weight of both lead and platinum, specific heat of lead being 0.0310 and of platinum 0.0324.

60. A l. of oxygen under standard conditions weighs 1.43 g. A l. of a certain element, the molecule of which contains 2 atoms, if vaporized under the same conditions, would weigh 11.43 g. What is the atomic weight of the element?

61. When 2.16 g. of silver are treated with chlorine, 2.87 g. of  $\text{AgCl}$  are formed; calculate the atomic weight of silver.

62. If 10 g. of the chloride of a certain univalent element are found to contain 60.6% of chlorine, and if the atomic weight of chlorine is 35.5, what is the atomic weight of the other element?

63. The molecular weight of potassium chloride is 74.2. The per cent of potassium in the compound is 52.56. The specific heat of potassium is 0.166. What is the atomic weight of the element?

64. The molecular weight of lead oxide,  $\text{PbO}$ , is 221.3. The per cent of lead = 92.81. Specific heat of lead = 0.031. What is its atomic weight?

65. A compound of hydrogen and sulphur has a molecular weight of 34. The per cent of sulphur in the compound is 94.11. Specific heat of sulphur = 0.163. What is its atomic weight?

66. A compound of aluminum and chlorine has a molecular weight of 265.2. Per cent of aluminum is 20.36. Specific heat of aluminum = 0.222. What is the atomic weight of aluminum?

67. Analysis of uranium chloride shows the composition: U, 62.7 % ; Cl, 37.3 %. The specific heat of metallic uranium is 0.027. What is the atomic weight of uranium and what the formula of the chloride?

68. Find the atomic weight of lead from the following data: the molecular weight of lead sulphide is 249; in 100 parts of lead sulphide there are 83.13 parts of lead; specific heat of lead is 0.031.

69. The molecular weight of arsenuretted hydrogen is 78. In 100 parts there are 96.15 parts of arsenic, and the specific heat of arsenic is 0.0814. What is the atomic weight of arsenic?

70. The molecular weight of carbon disulphide is 76, and 100 parts yield 84.21 parts of sulphur; the specific heat of sulphur is 0.163. What is the atomic weight of sulphur, and how many atoms of sulphur are in a molecule of the carbon disulphide?

71. The specific heat of silver is 0.056; what is its atomic weight?

72. If 35.5 g. of chlorine unite with 48.6 g. of platinum to form platinum chloride and the specific heat of platinum is 0.0324, what is (a) the atomic weight of platinum and (b) the formula of platinum chloride?

73. A compound consists of P, 20.19; O, 10.43; Cl, 69.38. The vapor density of the substance in the state of gas is 77.95; the specific heat of phosphorus is 0.1887. Calculate the molecular weight of the compound and the atomic weight of phosphorus.

74. Dumas found, on heating copper oxide in a stream of dry hydrogen, that a certain weight of this



substance lost 59.789 g. of oxygen and yielded 67.282 g. of water. Calculate from these numbers the atomic weight of hydrogen.

75. Marignac obtained 314.894 g. of silver nitrate from 200 g. of silver. Further, 14.110 g. of silver nitrate require 6.191 g. of potassium chloride for complete precipitation, and 10.339 g. of silver dissolved in nitric acid require 5.120 g. of ammonium chloride for precipitation. Calculate the atomic weight of nitrogen from these data.

76. An oxide of bismuth contains 89.655% of bismuth; calculate the equivalent of bismuth.

77. If 0.334 g. of metallic silver, dissolved in nitric acid, yield a precipitate of silver chloride with hydrochloric acid which weighed 0.4436 g., what is the equivalent of silver?

78. If 3.2 g. of silver chloride, heated in a current of hydrogen, yield 2.4081 g. of metallic silver, what is the equivalent of silver?

79. If 5 g. of copper oxide, heated in a current of hydrogen, yield 3.9915 g. of metallic copper, what is the equivalent of copper?

80. If 1.665 g. of lead chloride were dissolved in water, and silver nitrate was added to the solution, and the precipitated silver chloride weighed 1.72 g., what is the equivalent of lead?

81. Mallet found that 8.2144 g. of ammonium alum, dried by exposure to air at  $+21^{\circ}\text{C.}$  to  $+25^{\circ}\text{C.}$ , yielded 0.9258 g. of  $\text{Al}_2\text{O}_3$ . Taking the following atomic weights: O, 15.961; S, 31.966; N, 14.010, find the atomic weight of aluminum.

82. Mallet found that 6.9617 g. of  $\text{AlBr}_3$  required 8.4429 g. of Ag for precipitation of the bromine. If  $\text{Ag} = 107.649$  and  $\text{Br} = 79.754$ , what is the atomic weight of Al as deduced from this result?

83. Find the equivalent of aluminum from the following data: (a) 5.2632 g. of the metal heated with potash gave hydrogen which, when burned, yielded 5.2562 g. of water; (b) 8.6492 g. of aluminum bromide required 10.4897 g. of silver for complete precipitation.

84. One l. of mercury vapor at the standard temperature and pressure weighs 8.923 g. On heating 118.3938 g. of mercuric oxide, Erdmann and Marchand obtained 109.6308 g. of mercury. On the assumption that mercuric oxide is formed by the union of 1 atom of mercury with 1 atom of oxygen, what light do these facts throw on the atomic and molecular weights of mercury?

85. By dissolving 0.4442 g. of metallic cobalt in an acid, 177.4 cc. of hydrogen at  $+10^\circ \text{C}$ . and 750 mm. pressure are obtained. The specific heat of the metal is 0.107. Calculate the atomic weight of cobalt.

86. If 4.353 g. of potassium bromide required, for complete precipitation, 3.946 g. of silver dissolved in nitric acid, what is the equivalent of bromine?

87. A compound has the following percentage composition: oxygen, 76.09 %; hydrogen, 1.59 %; nitrogen, 22.32 %. One l. of its vapor weighs 2.817 g. What is its molecular weight and formula?

88. A hydrocarbon consists of carbon, 93.75 %; hydrogen, 6.25 %. The density (air) of its vapor is 4.456. What is its formula?

89. A gas has the following composition: nitrogen, 30.56 %; oxygen, 69.44 %. One l. of the gas weighs 2.058 g. What is its molecular weight and formula?

90. A compound has the following percentage composition: H, 1.19 %; O, 56.86 %; Cl, 41.95 %. One l. of its vapor weighs 3.771 g. What is its molecular weight and formula?

91. If 4.5 g. of mercury unite with oxygen to form 4.86 of mercuric oxide, and the specific heat of mercury is 0.032, what is its atomic weight?

92. If 25 g. of metallic tin were converted into stannic oxide by heating with nitric acid and then igniting, and the stannic oxide weighed 31.8 g., what is its atomic weight? The specific heat of tin is 0.056.

93. Suppose that 0.3697 g. of aluminum liberated 0.04106 g. of hydrogen on being dissolved in a strong solution of sodium hydrate. On the assumption that alumina is a sesquioxide,  $\text{Al}_2\text{O}_3$ , find from these data the atomic weight of aluminum.

## CHAPTER XI

### Electro-chemical Problems

1. A current deposits 16 g. of silver; how much copper will it deposit?

2. What current strength (in amperes) is required to deposit: 20 g. of silver in an hour; 100 g. of iodine in 5 minutes; 60 g. of antimony in 3 hours?

3. A current deposits 1 g. of sodium; find weight of Ni deposited.

4. If a current deposits 32 g. of Cu, how many g. of Al, Na, Mg, Pb, will it deposit?

5. Two electrolytic cells, one containing acidulated water and the other lead nitrate solution, are joined in series, and the same current is passed through them until 25 cc. of hydrogen are liberated in the first cell. What weight of lead nitrate will be decomposed in the other cell?

6. How many g. of silver will be deposited from a solution of silver nitrate by a current of 2 amperes in 50 sec.?

7. How many g. of copper will be deposited from a bath of copper sulphate by a current of 5 amperes in 30 min.?

8. How much would a metal platter increase in weight if it were nickel-plated by a current of 0.5 ampere running 5 hr.?

9. What is the current strength of a Daniell cell if its copper plate gains 0.7 g. in 40 min.?

10. How much current would be needed to make in 3 hr. a copper electrotype shell weighing 40 g.?

11. How long would it take a current of 5 amperes to produce 0.6 g. of hydrogen by decomposition of water?

12. Find the electro-chemical equivalent for zinc from the fact that one of the zinc plates in an Edison chemical meter gains 726 g. when 20 amperes pass through it for 30 hr.

13. If a current of 2 amperes is used to decompose water and produces 2.981 g. of oxygen in 5 hr., what is the electro-chemical equivalent for oxygen?

14. The current from a battery liberates in a given time 150 cc. (measured at  $0^{\circ}\text{C}$ . and 760 mm.) of the mixed gases from acidified water; if this same current were passed through a solution of copper sulphate, what weight of copper would be deposited?

15. How many coulombs are carried by and will deposit: 20 g. of silver; 15 g. of antimony; 30 g. of chlorine; 60 g. of phosphanion ( $\text{PO}_4$ )?

16. If a current of 15 amperes flows for 1 hour and 20 minutes, how many coulombs will pass? How many ampere-hours will that give?

17. If the specific resistance of copper is 0.000001629, what is the resistance of a wire 200 m. long having a cross section of 2 mm.<sup>2</sup>?

18. If the specific resistance of German silver is 0.0000209, what is the resistance of 150 m. of wire having a cross section of 25 mm.<sup>2</sup>?

19. What is the resistance of an electric light carbon 12 inches long by  $\frac{1}{4}$  inch in diameter, when its specific resistance is 0.07?

20. How much zinc will be deposited from zinc sulphate by 3 amperes in 10 minutes?

21. How much lead will be deposited by a current of  $\frac{1}{2}$  an ampere passing for 90 minutes through lead chloride?

22. How much chlorine would be liberated by  $\frac{1}{2}$  an ampere passing through dilute hydrochloric acid for 13 hours?

23. How much tin will be deposited by 5 amperes flowing 6 hours through a solution of  $\text{SnCl}_2$ ?

24. How many amperes will it take to deposit  $2\frac{1}{2}$  lb. of copper from copper sulphate in 10 hours?

25. What is the minimum voltage necessary to decompose water if the heat of combination of 1 g. of hydrogen with oxygen is 34,180 calories?

26. If zinc bromide requires 1.65 volts to decompose it, what is the heat involved by the equivalent weight of zinc in g. combining with bromine?

27. If 1 g. of hydrogen, combining with chlorine in the presence of water, evolves 39,315 calories, what is the voltage required for the decomposition of hydrochloric acid?

## CHAPTER XII

### Analytical Calculations — Strength of Solutions

1. If a solution of hydrochloric acid contained 44 g. of that substance to the l., how many cc. of the solution would be needed to neutralize 20 cc. of the solution of sodium hydroxide containing 60 g. to the l.?

2. What weight of sodium hydroxide will neutralize 100 g. of sulphuric acid? What weight of potassium hydroxide will neutralize the same?

3. If in neutralizing a certain amount of nitric acid with sodium hydroxide, 7.85 cc. of water are formed, how much nitric acid and how much sodium hydroxide have been employed?

4. How many g. of a 5 % solution of KOH will be required to neutralize 10 g. of a 10 % solution of  $\text{H}_2\text{SO}_4$ ?

5. If 10 g. of commercial caustic soda, dissolved in water, required 116.3 g. of a 10 % sulphuric acid to neutralize the solution, what percentage of pure NaOH did the substance contain?

6. If 10 g. of commercial nitric acid were exactly neutralized by the addition of 58.6 g. of a 10 % solution of potassium hydroxide, what was the strength of the acid in pure  $\text{HNO}_3$ ?

7. If a solution contained 50 g. of ammonium hydroxide to the l., how many cc. of a 10 % solution of hydrochloric acid will be needed to neutralize 60 cc. of the ammonium hydroxide solution?
8. What weight of potassium hydroxide will neutralize 36.2 g. of hydrochloric acid?
9. What weight of sodium hydroxide will neutralize 36.2 g. of hydrochloric acid?
10. What weight of potassium hydroxide will neutralize 62.7 g. of nitric acid?
11. What weight of sodium hydroxide will neutralize 62.7 g. of nitric acid?
12. What weight of potassium hydroxide will neutralize 97.6 g. of sulphuric acid?
13. What weight of sodium hydroxide will neutralize 97.6 g. of sulphuric acid?
14. Suppose we have a molar solution of sodium hydroxide and a hydrogen chloride solution of unknown strength. If 50 cc. of the former require 62 cc. of the latter for neutralization, what is the strength of the hydrochloric acid solution?
15. Calculate the weight of sodium hydroxide that would be neutralized by 50 cc. of a solution of sulphuric acid of density 1.23 and containing 31% by weight of pure acid.
16. What volume of centinormal sulphuric acid solution would be required to neutralize 0.008 g. of  $K_2CO_3$ ?
17. HBr solution having a density of 1.515 contains 49.8 % of the gas. How many g.  $AgNO_3$  are needed to precipitate 250 cc. of the solution?



18. If 75 cc. of HCl solution neutralize 60 cc. of NaOH containing 0.003 g. of the alkali per cc., what was the weight of the acid in 1 cc. of its solution?

19. A solution of KOH contains 0.02 g. per cc. and 15 cc. of it neutralize 40 cc. of an HCl solution. Find the number of g. of HCl contained in 30 cc. of the solution.

20. How much ammonium hydroxide, sp. gr. 0.88, and water will have to be mixed to give 200 cc. of ammonium hydroxide, sp. gr. 0.96?

21. How much nitric acid, sp. gr. 1.42, and water are needed to make 6 l. of nitric acid, sp. gr. 1.26?

22. How much sulphuric acid, sp. gr. 1.7, and how much water are required to make 400 cc. of sp. gr. 1.18?

23. How much ammonium hydroxide, sp. gr. 0.9, and water must be mixed to give 4 l. of sp. gr. 0.96?

24. Given 2 l. of dilute sulphuric acid, sp. gr. 1.2, which is to be used up in diluting concentrated sulphuric acid, sp. gr. 1.82, to an acid of sp. gr. 1.3, how much concentrated acid must be added?

× 25. A solution of lime water contains 5 g. of lime to the l.; how many cc. of N/10  $\text{H}_2\text{SO}_4$  are needed to precipitate all of the lime from 10 l. of the lime water solution?

× 26. If 300 cc. of a solution of caustic potash containing 40 g. KOH per l. are required to neutralize 100 cc. of sulphuric acid and the same volume of nitric acid, what is the amount of acid in each solution?

× 27. What volume of aqueous hydrochloric acid, containing 36.5 g. HCl per l., will be required to neutralize 224.5 g. of  $\text{Na}_2\text{CO}_3$ ,  $10 \text{ H}_2\text{O}$ ?

× 28. How many lb. of 15 % HCl are needed to neutralize 2000 lb. of  $\text{Na}_2\text{CO}_3$ ?

× 29. Calculate the weight of crystallized oxalic acid ( $\text{C}_2\text{H}_2\text{O}_4, 2 \text{H}_2\text{O}$ ) required for a solution which is to be made up to 500 cc. in volume at N/2 strength.

30. If 1 l. of a solution of sodium hydroxide contains 35 g. of NaOH, how many g. of nitric acid would be needed to neutralize exactly 60 cc. of the solution?

31. How much of the following substances are in their molar solutions: hydrogen bromide; potassium hydroxide; and potassium iodide?

32. How much of a tenth-normal hydrochloric acid solution is necessary to neutralize 3 g. of strontium hydroxide?

33. Determine the normality of a sodium dichromate solution, 50 cc. of which oxidized 3.85 g. of ferrous ammonium sulphate [ $\text{FeSO}_4, (\text{NH}_4)_2\text{SO}_4, 6 \text{H}_2\text{O}$ ] to the ferric salt.

34. How many g. of 10 % (by weight) solution of barium chloride are needed to precipitate as barium sulphate the  $\text{SO}_4$  in 2 g. of pure magnesium sulphate?

35. How many g. of a 5 % solution of ammonium oxalate are needed to precipitate completely as calcium oxalate the lime in 1 g. of calcium carbonate?

36. How many g. of 15 % solution of  $\text{NaNH}_4\text{HPO}_4$  are necessary to precipitate completely the zinc in a solution containing 0.50 g. of zinc?

37. How many lb. of 25 % sulphuric acid will be required to neutralize 2000 lb. of  $\text{NaHCO}_3$ ; of  $\text{CaCO}_3$ ?

38. How much iron is present in 10 cc. of ferrous sulphate solution, 15 cc. of which required 60 cc. of a solution of  $\text{K}_2\text{Cr}_2\text{O}_7$  containing 4.902 g. of the dry salt per l.?

39. A solution, *A*, contains 100 g. of KOH to the l. A solution, *B*, contains 100 g. of  $\text{H}_2\text{SO}_4$  to the l. What volume of solution *A* is needed to neutralize exactly 25 cc. of *B*?

40. Calculate the number of g. per l. to give normal solutions of NaCl; of  $\text{BaCl}_2$ ; of  $\text{Na}_3\text{PO}_4$ ; of KOH.

41. Calculate the amounts needed to make 5 l. of N/10 silver nitrate; 2 l. of N/10 sodium bromide; 1 l. of N/20  $\text{K}_2\text{CO}_3$ .

42. What weight of iron in the ferrous condition will 100 cc. of N/10  $\text{KMnO}_4$  oxidize?

43. 4 g. of pure  $\text{KMnO}_4$  are dissolved and diluted to 1 l.; how many mg. of active oxygen are contained in each cc.? What will be its strength in terms of iron; of oxalic acid?

44. If 35 g. of  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$  are dissolved and diluted to 1 l., how many mg. of active oxygen will each cc. absorb?

45. How many g. of NaOH must be added to 2 l. of NaOH solution, the strength of which is 1 cc. = 0.045 g.  $\text{H}_2\text{SO}_4$ , to make it a normal solution? How much water to make it N/2 solution?

46. How many g. per l. of  $\text{KMnO}_4$  will give a solution of such strength that 1 cc. = 1% of iron when 0.5 g. is taken for analysis?

47. Given a solution of  $\text{K}_2\text{Cr}_2\text{O}_7$ , 1 cc. = 0.005 g. iron, how many g. of  $\text{KMnO}_4$  per l. will give a solution of equal oxidizing strength?

48. What volumes of  $N/2$  and of  $N/10$   $H_2SO_4$  must be mixed to give 2 l. of  $N/5$   $H_2SO_4$ ?

49. A solution of hydrochloric acid is desired to be made exactly normal. If 40 cc. of the solution neutralized 50 cc. of 0.84 N sodium hydroxide solution, what volume of water must be added per 100 cc. of the acid solution?

50. A solution of sodium hydroxide is desired to be made exactly 0.5 N. If 32 cc. of the solution at hand were required for the titration of 28 cc. of 0.8 N hydrochloric acid, what volume of water must be added per 100 cc. of the alkaline solution?

51. A solution of sodium carbonate is desired to be made exactly 0.05 N. If 24 cc. of the solution at hand neutralized 9.6 cc. of 0.12 N hydrochloric acid solution, what weight of anhydrous salt,  $Na_2CO_3$ , must be added per 100 cc. of solution?

52. Calculate the volume of nitric oxide that could be evolved by the action of copper upon 1000 cc. of a  $N/7$  nitric acid solution.

53. An excess of iron sulphide was added to 500 cc. of a solution of sulphuric acid. The volume of hydrogen sulphide set free measured 4640 cc. Calculate the normality of the acid.

54. An excess of sodium sulphite was added to 400 cc. of a solution of hydrochloric acid. The volume of sulphur dioxide set free measured 5600 cc. Calculate the normality of the acid.

55. Suppose that 1400 cc. of ammonia were passed into 500 cc. of  $N/2$  hydrochloric acid solution. Calculate the normality of the hydrochloric acid still present.

56. If 50 cc. of  $N/5$  hydrochloric acid solution neutralized 40 cc. of an unknown alkaline solution, and 300 cc. of a sulphuric acid solution neutralized 60 cc. of this same alkaline solution, what is the normality of the sulphuric acid?

57. If 200 cc. of a barium hydroxide solution were required in the titration of 40 cc. of an acid solution, and 100 cc. of this acid solution exactly neutralized 80 cc. of  $N/2$  alkaline solution, what is the normality of the barium hydroxide solution?

58. If 600 cc. of a sulphuric acid solution, when acted upon by an excess of zinc, evolved 1242 cc. of hydrogen, what is the normality of the acid?

59. If 400 cc. of an acid solution, when acted upon by an excess of zinc, evolved 2430 cc. of hydrogen, measured over water at  $+21^{\circ}\text{C}$ . and 747.5 mm., what is the normality of the acid?

60. Calculate the normality of a solution of potassium carbonate, 200 cc. of which, when treated with an excess of acid, evolved 4502 cc. of carbon dioxide.

61. A slight excess of barium chloride solution was added to 400 cc. of a solution of sulphuric acid. From the weight of barium sulphate precipitated, 4.12 g., calculate the normality of the acid.

62. If 50 cc. of a solution of hydrogen peroxide were required to decolorize 400 cc. of  $N/5$  potassium permanganate solution (acidulated), what is the percentage concentration of the hydrogen peroxide solution?

63. Calculate the weight of a crystallized oxalic acid required for the reduction of 100 g. of potassium permanganate in acid solution. What volume of carbon dioxide, at standard conditions, would be liberated?

64. If 400 cc. of N/4 potassium hydroxide solution were required for the neutralization of 600 cc. of an unknown acid solution, what is the normality of this acid solution?

65. If 500 cc. of N/10 acid solution were required for the neutralization of 25 cc. of a solution of sodium hydroxide, what is the normality of this latter solution?

66. What volume of N/10 acid solution will be required in the titration of 440 cc. of N/4 sodium hydroxide solution?

67. What volume of N/6 alkaline solution will be required in the titration of 254 cc. of N/10 acid solution?

68. Calculate the weight of hydrogen chloride present in 400 cc. of a hydrochloric acid solution which required 320 cc. of N/4 alkaline solution for titration.

69. Calculate the weight of sulphuric acid present in 150 cc. of a solution which required 48.1 cc. of 0.78 N alkali for titration.

70. An excess of silver nitrate solution was added to 350 cc. of a solution of hydrochloric acid. The precipitate of silver chloride weighed 7.54 g. Calculate the normality of the acid.

71. The bromine set free by the action of manganese dioxide upon a hydrobromic acid solution was passed into a solution of potassium iodide. If 200 cc. of N/10 sodium thiosulphate solution were required for the titration of the free iodine, what is the weight of the bromine evolved?

72. Determine the purity of a sample of manganese dioxide, 2.2 g. of which, with excess of hydrochloric

acid, set free sufficient chlorine to liberate a quantity of iodine that required 250 cc. of N/5 sodium thiosulphate solution for titration.

✓ 73. What weight of iron will be required for interaction with 400 cc. of N/5 hydrochloric acid?

74. What weight of sodium carbonate will be required for interaction with 600 cc. of N/8 sulphuric acid? What volume of carbon dioxide (at standard conditions) will be evolved?

75. What weight of sodium hydrogen carbonate,  $\text{NaHCO}_3$ , will be required for interaction with 600 cc. of N/8 sulphuric acid? What volume of carbon dioxide will be evolved?

76. If 50 cc. of an acidulated potassium permanganate solution were reduced by 2.4 g. of anhydrous oxalic acid, what is the normality of the permanganate solution?

77. What weight of sulphur dioxide will be oxidized by 50 g. of potassium permanganate in alkaline solution?

78. What weight of sodium dichromate must enter into reaction with a hydrochloric acid solution in order to liberate 100 g. of chlorine at standard conditions?

79. Determine the normality of a potassium dichromate solution, 25 cc. of which oxidized 1.24 g. of ferrous sulphate to the ferric salt.

80. What volume of hydrogen sulphide, at  $+24^\circ \text{C}$ . and 750 mm. pressure, can be oxidized by 10 g. of potassium dichromate in acid solution?

81. What weight of potassium dichromate, in acid solution, will be reduced by 1653.5 cc. of sulphur dioxide at  $+22^\circ \text{C}$ . and 745 mm. pressure?

82. What volume of hydrogen sulphide will be required for the reduction of 100 g. of ferric chloride,  $\text{FeCl}_3$ , to the ferrous salt?

83. What volume of gaseous product may be obtained in the decomposition of 100 cc. of ammonia by heated cupric oxide?

84. What volume of hydrogen sulphide will be required to reduce 200 cc. of N/10 potassium dichromate solution (acidulated)?

85. Calculate the volume of hydrogen sulphide, at standard conditions, that can be oxidized by 4 g. of potassium permanganate in acid solution.

86. What weight of sulphur dioxide can be oxidized by 200 g. of potassium permanganate in acid solution?

87. A sample of sodium chromate, weighing 1.6780 g., gave upon analysis 1.4620 g. of sodium sulphate. What was the percentage of sodium oxide in the sample?

88. Calculate the weight of sulphur precipitated in the reduction of 100 g. of ferric chloride to the ferrous salt by the action of hydrogen sulphide.

89. What weight of potassium dichromate will 1000 cc. of hydrogen sulphide reduce in acid solution?

90. Calculate the percentage purity of a quantity of potassium ferrocyanide, 0.5793 g. of which gave upon analysis 0.4650 g. of potassium sulphate.

91. What is the percentage of potassium sulphate in a sample of common alum which analyzed 33.51% sulphur trioxide?



92. What is the percentage of copper carbonate in a sample of malachite which on analysis gave 57.1 % copper ?

93. A sample of carnallite ( $\text{KCl}$ ,  $\text{MgCl}_2$ ,  $6 \text{ H}_2\text{O}$ ) on analysis gave 35.34 % chlorine ; what is the percentage of magnesium chloride present ?

94. Calculate the percentage purity of a sample of marble which on analysis gave 39.6 % calcium.

95. Calculate the percentage of potassium chloride in a sample of carnallite ( $\text{KCl}$ ,  $\text{MgCl}_2$ ,  $6 \text{ H}_2\text{O}$ ) which on being analyzed gave 37.72 % chlorine.

96. Calculate the percentage of calcium oxide,  $\text{CaO}$ , present in a sample of marble,  $\text{CaCO}_3$ , which on being analyzed gave 43.8 % carbon dioxide.

97. Two g. of impure potassium dicarbonate required, when titrated cold, in a dilute solution, 6 cc. of  $\text{N}/10 \text{ H}_2\text{SO}_4$ ; 2 g., when titrated boiling hot, required 18 cc. of normal  $\text{H}_2\text{SO}_4$ . What are the percentages of  $\text{K}_2\text{CO}_3$  and of  $\text{KHCO}_3$ ?

98. What volumes of  $\text{N}/2$  and of  $\text{N}/10 \text{ H}_2\text{SO}_4$  must be mixed to give 2 l. of  $\text{N}/5 \text{ H}_2\text{SO}_4$ ?

99. A  $\text{N}/10$  iodine solution is 2 % too strong. How many cc. of a  $\text{N}/100$  iodine solution must be added to 1 l. to make it right?

100. How much more normal  $\text{NaOH}$  will it take to neutralize 1 g. of  $\text{NaHSO}_4$  than normal  $\text{KOH}$  to neutralize 1 g.  $\text{KHSO}_4$ ?

101. Suppose that 0.2 g. of a nitrogenous organic compound were heated with soda lime and the  $\text{NH}_3$  evolved was caught in 50 cc.  $\text{N}/10 \text{ HCl}$ , and that the excess of  $\text{HCl}$  was neutralized by 14 cc. of  $\text{N}/5 \text{ NaOH}$ ; what was the percentage of nitrogen?

**102.** In 1 g. of an antimony alloy the antimony was determined by N/10  $\text{Na}_2\text{S}_2\text{O}_3$  and 24.2 cc. were required; what is the percentage of antimony?

**103.** What amount of type metal must be taken for analysis so that the burette shall read percentage of antimony when N/10  $\text{Na}_2\text{S}_2\text{O}_3$  is used?

**104.** Five g. of bleaching powder were mixed in a mortar with water and diluted to 1 l.; 50 cc. of this required 30 cc. of N/10  $\text{Na}_3\text{AsO}_3$  solution. What is the percentage of available chlorine? Under these conditions, what fraction of normal will read percentage direct?

**105.** To 50 cc. of a solution of chlorine an excess of potassium iodide was added; the liberated iodine was then estimated by a N/10 solution of  $\text{Na}_2\text{S}_2\text{O}_3$ , starch being used as an indicator; and 22.5 cc. of  $\text{Na}_2\text{S}_2\text{O}_3$  solution were needed. What is the strength of the chlorine solution?

**106.** How much more normal NaOH will it take to neutralize 1 g. of HCl than 1 g. of HBr?

**107.** How many g. per l. of  $\text{K}_2\text{Cr}_2\text{O}_7$  will give a solution of such strength that 1 cc. = 1 % of iron when 0.60 g. is taken for analysis?

**108.** How many g. of  $\text{Na}_2\text{S}_2\text{O}_3$ , 5  $\text{H}_2\text{O}$  per l. will give a solution such that 1 cc. = 0.5 % Cu when 1 g. is taken for analysis?

**109.** How much water must be added to 2 l. of  $\text{KMnO}_4$ , 1 cc. = 0.0065 g. iron, to make it N/10?

**110.** How much water must be added to 3 l. of  $\text{K}_4\text{Fe}(\text{CN})_6$ , 1 cc. = 0.0115 g. zinc, to make it read percentage directly when 1 g. is taken for analysis?

**111.** Given a solution of  $\text{K}_2\text{Cr}_2\text{O}_7$ , 1 cc. = 0.0042 g. Fe, how many g. per l. of  $\text{KMnO}_4$  will give a solution of equal strength?

**112.** Given a solution of  $\text{KMnO}_4$ , 1 cc. = 0.0056 g. of iron, what is its strength in terms of manganese by the Volhard method and by the Ford-Williams method?

**113.** What is the strength of N/10  $\text{KMnO}_4$  in terms of  $\text{H}_2\text{C}_2\text{O}_4$ ; of  $\text{CaO}$ ; of  $\text{CaCO}_3$ ; of  $\text{CaSO}_4$ ?

**114.** What is the strength of N/10  $\text{KMnO}_4$  in terms of P and of  $\text{MoO}_3$  according to Noyes' method?

**115.** What is the strength of a N/10 sodium thio-sulphate solution in terms of iodine; of copper?

**116.** What is the strength of a N/5 iodine solution in terms of  $\text{SO}_2$ ;  $\text{H}_2\text{SO}_3$ ;  $\text{Na}_2\text{SO}_3$ ?

**117.** How many cc. of N/5  $\text{Na}_2\text{S}_2\text{O}_3$  solution will be required to react with the iodine liberated by 20 cc. of a N/10  $\text{K}_2\text{Cr}_2\text{O}_7$  solution?

**118.** How many g. of copper will give, when precipitated by potassium iodide, sufficient iodine to require 20 cc. of N/10  $\text{SO}_2$  solution? How many for 10 cc. of N/10  $\text{Na}_2\text{S}_2\text{O}_3$  solution?

**119.** Five g. of pig iron took 12 cc. of N/100 iodine solution; what is the percentage of sulphur?

**120.** If 1.5 g. of pig iron took 78 cc. of N/10  $\text{KMnO}_4$ , what is the percentage of phosphorus?

**121.** How much  $\text{NaOH}$  must be added to 1.890 l. of  $\text{NaOH}$  solution, the strength of which is 1 cc. = 0.045 g.  $\text{H}_2\text{SO}_4$ , to make it normal? How much water to make it N/2?

122. One g. of a rock gave, on analysis: combined sodium and potassium sulphates, 0.150 g.; and platinum from  $K_2PtCl_6$ , 0.1127 g. What are the percentages of  $K_2O$  and  $Na_2O$ ?

123. Which is more economical for neutralizing an alkali, 60 %  $HNO_3$  at 6 cts. per lb. or 20 %  $HCl$  at 3 cts. per lb.?

124. Which is the more economical oxidizing agent,  $KNO_3$  at 5 cts. a lb. or  $NaNO_3$  at  $5\frac{1}{2}$  cts. a lb.?

125. Calculate the number of g. per l. to give normal solutions of oxalic acid; of tartaric acid; of acetic acid; of citric acid.

126. Calculate the number of g. per l. to give half normal solutions of I; of  $Na_2S_2O_3$ , 5  $H_2O$ ; of  $SO_2$ .

127. Calculate the amounts necessary to make 2 l. of N/10  $NaCl$  and  $NaBr$ .

128. Calculate the strength of N/20  $KMnO_4$  to be used in titrating  $K_4Fe(CN)_6$ .

129. What is the strength of N/10  $KMnO_4$  in terms of Fe;  $Fe_2O_3$ ;  $Fe_3O_4$ ;  $FeSO_4$ , 7  $H_2O$ ?

130. How many g. of oxalic acid in a molar and in a normal solution?

131. How many cc. of a N/3 solution of  $AgNO_3$  will precipitate 20 cc. of a 10 % sodium chloride solution?

132. What weight of  $As_2O_3$  will be necessary to make a twice molar and a N/2 solution?

133. One g. of coal gave 0.2634 g. of  $BaSO_4$  by Eschka's Method; 1 g. of  $MgO$  and 0.5 g. of  $Na_2CO_3$  were used. It was found that both contained sulphur;

10 g. of  $\text{MgO}$  and 5 g. of  $\text{Na}_2\text{CO}_3$  (together) gave 0.1654 g. of  $\text{BaSO}_4$ . What is the percentage of sulphur in the coal?

134. Suppose that 1 g. of silver is dissolved in nitric acid and to it is added 0.25 g. of pure dry sodium chloride. What percentage of the silver remains in solution?

135. Suppose that 0.25 g. of sodium bromide is added to a solution of 1 g. of silver; what percentage of silver remains in solution?

136. A dolomite contains 98% of calcium and magnesium carbonates, 2% of  $\text{SiO}_2$ , and 10% of  $\text{MgO}$ ; what is the percentage of  $\text{CO}_2$ ?

137. Calculate the chemical factors for (a)  $(\text{NH}_4)_2\text{O}$  from  $2\text{NH}_4\text{Cl}$ ,  $\text{PtCl}_4$ ; (b) for K in  $2\text{KCl}$ ,  $\text{PtCl}_4$ ; (c) for P in  $\text{Mg}_2\text{P}_2\text{O}_7$ ; (d) for  $\text{Fe}_2\text{O}_3$  from  $\text{Fe}_3\text{O}_4$ .

138. If 0.5 g. of platinum remains after the ignition of the precipitate of the double salt,  $2\text{NH}_4\text{Cl}$ ,  $\text{PtCl}_4$ , derived from 1 g. of an ammonium compound, calculate the percentage of  $\text{NH}_3$  in the latter.  $2\text{NH}_4\text{Cl}$ ,  $\text{PtCl}_4 = 2\text{NH}_3 + 2\text{HCl} + 2\text{Cl}_2 + \text{Pt}$ .

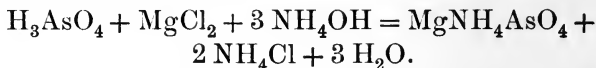
139. What weight of  $\text{Mn}_3\text{O}_4$  corresponds to 1 g. of  $\text{Mn}_2\text{P}_2\text{O}_7$ ?

140. How many cc. of aqueous ammonia (sp. gr. = 0.96), containing 9.90% of  $\text{NH}_3$  by weight, will be required to precipitate the iron as  $\text{Fe}(\text{OH})_3$  from 1 g. of  $(\text{NH}_4)_2\text{SO}_4$ ,  $\text{FeSO}_4$ ,  $6\text{H}_2\text{O}$ ?

141. How many cc. of  $\text{HNO}_3$  (sp. gr. = 1.135), containing 20% of  $\text{HNO}_3$  by weight, are required to oxidize the iron in 1 g. of  $\text{FeSO}_4$ ,  $(\text{NH}_4)_2\text{SO}_4$ ,  $6\text{H}_2\text{O}$ , in the presence of sulphuric acid?  $6\text{FeSO}_4 + 2\text{HNO}_3 + 3\text{H}_2\text{SO}_4 = 3\text{Fe}_2(\text{SO}_4)_3 + 2\text{NO} + 4\text{H}_2\text{O}$ .

**142.** The ignited precipitate of  $\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$  from 1.5 g. of a silicate weighs 0.4069 g.; this mixture loses 0.0200 g. when ignited in hydrogen. What is the percentage of  $\text{Fe}_2\text{O}_3$  and  $\text{Al}_2\text{O}_3$  in the sample?  $\text{Fe}_2\text{O}_3 + 3 \text{H}_2 = 2 \text{Fe} + 3 \text{H}_2\text{O}$ .

**143.** How many cc. of "magnesia mixture" (64 g.  $\text{MgCl}_2$  per l.) will be required to precipitate the arsenic from 0.2 g.  $\text{As}_2\text{S}_3$  after oxidation to arsenic acid?



**144.** How many cc. of sulphuric acid (sp. gr. = 1.75), containing 81 %  $\text{H}_2\text{SO}_4$  by weight, are necessary to replace the nitric acid in the nitrates formed from 5 g. of a brass containing 65 % Cu, 34.5 % Zn, and 0.5 % Pb?

**145.** If 5.23 g. of brass yield 0.0345 g. of  $\text{PbSO}_4$ , and subsequently 0.0031 g. of  $\text{PbO}_2$  on electrolysis of the filtrate, what is the percentage of Pb in the brass?

**146.** If in the analysis of a brass containing 65 % copper, an error is made in weighing a 5 g. portion, by which 0.001 g. too much is weighed out, what would be the percentage of copper as determined? If the same error is made in weighing 0.2 g. of apatite containing 40 %  $\text{P}_2\text{O}_5$ , what will be the apparent percentage? What will be the percentage error in each case?

**147.** If the dry cupric sulphide from 0.82 g. of brass loses 0.1345 g. on ignition in hydrogen, what is the percentage of copper in the brass?  $2 \text{CuS} = \text{Cu}_2\text{S} + \text{S}$ .

**148.** If 1.5 g. of glass yield 0.38 g.  $\text{KCl} + \text{NaCl}$ , from which 0.646 g.  $2 \text{KCl}$ ,  $\text{PtCl}_4$  is obtained, what is the percentage of  $\text{Na}_2\text{O}$  in the glass?

**149.** How many cc. of an ammonium oxalate solution  $[(\text{NH}_4)_2\text{C}_2\text{O}_4, \text{H}_2\text{O}]$  (40 g. per l.) are required to precipitate the calcium as oxalate from 1 g. of apatite  $[\text{Ca}_3(\text{PO}_4)_2, \text{CaCl}_2]$ ? How many cc. of "magnesia mixture" (containing 64 g.  $\text{MgCl}_2$  per l.) are necessary to combine with the phosphoric acid in the same weight of apatite?

**150.** If a calcium oxalate precipitate (which is contaminated by silica) from 0.83 g. of dolomite is ignited under such conditions that the decomposition products may be passed through  $\text{Ba}(\text{OH})_2$  solution, and the resulting precipitate of barium carbonate is found, on drying, to weigh 0.9500 g., what is the percentage of  $\text{CaO}$  in the sample?

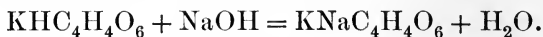
**151.** How many cc. of a potassium tetroxalate solution ( $\text{KHC}_2\text{O}_4, \text{C}_2\text{H}_2\text{O}_4, 2 \text{H}_2\text{O}$ ), containing 50 g. per l., would be required to precipitate the calcium from 1 g. of a sample of dolomite yielding 2%  $\text{Fe}_2\text{O}_3$ , 10%  $\text{MgO}$ , and 45%  $\text{CO}_2$ , assuming the iron, magnesium, and calcium to be present wholly as carbonates, the iron as ferrous carbonate?

**152.** A mixture of  $\text{BaO}$  and  $\text{CaO}$  weighing 0.2438 g. yields 0.4876 g. of mixed sulphates. What is the weight of each oxide in the original mixture?

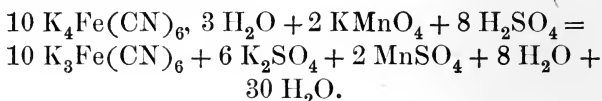
**153.** Calculate the percentage of pure  $\text{Na}_2\text{CO}_3$  in an impure sample from the following data: crucible +  $\text{SiO}_2 = 20.0697$  g.; crucible +  $\text{SiO}_2 + \text{Na}_2\text{CO}_3$  (impure) = 20.3264 g.; crucible +  $\text{SiO}_2$  (excess) +  $\text{Na}_2\text{SiO}_3$  (after fusion) = 20.2239 g. Assume the reaction to be  $\text{Na}_2\text{CO}_3 + \text{SiO}_2 = \text{Na}_2\text{SiO}_3 + \text{CO}_2$ .

**154.** A sample of pyrite weighing 0.5 g. yields 1.6 g.  $\text{BaSO}_4$ . Calculate the per cent of  $\text{FeS}_2$  in the sample.

**155.** How much crude cream of tartar should be taken for an analysis in order that the number of cc. of N/2 NaOH solution required to react with it shall represent directly the percentage of  $\text{KHC}_4\text{H}_4\text{O}_6$ ? How much oxalic acid in order that each cc. of N/10  $\text{KMnO}_4$  may represent 1%  $\text{C}_2\text{H}_2\text{O}_4$ , 2  $\text{H}_2\text{O}$ ?



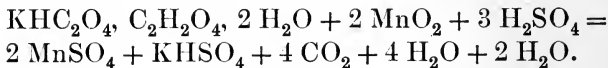
**156.** What weight of potassium ferrocyanide [ $\text{K}_4\text{Fe}(\text{CN})_6, 3 \text{H}_2\text{O}$ ] should a normal solution contain for use as a reducing agent?



**157.** Calculate the percentage of carbon dioxide in a sample of calcium carbonate from the following data:

Total volume N/2 HCl = 35 cc.; total volume N/10 NaOH = 15 cc.; weight carbonate = 1.00 g.

**158.** Calculate the weight of  $\text{KHC}_2\text{O}_4$ ,  $\text{C}_2\text{H}_2\text{O}_4$ , 2  $\text{H}_2\text{O}$  necessary for a l. of normal solution, (a) as a standard acid solution, (b) as a reducing agent.



**159.** Given the following data, calculate the percentage purity of the oxalic acid:

Standardization: weight  $\text{CaCO}_3$  = 1.050 g.; HCl solution used = 45 cc.; NaOH solution used = 4.8 cc.; 1 cc. NaOH solution = 1.042 cc. HCl solution.

Analysis: weight oxalic acid = 1.500 g.; NaOH solution used = 42.5 cc.; HCl solution used = 0.5 cc.

**160.** Given the following data, calculate the percentage purity of the cream of tartar ( $\text{KHC}_4\text{H}_4\text{O}_6$ ):



Weight of substance = 2.500 g.; NaOH solution used = 25.51 cc.;  $\text{H}_2\text{SO}_4$  solution used = 0.5 cc.; 1 cc.  $\text{H}_2\text{SO}_4$  solution = 1.02 cc. NaOH solution; 1 cc. NaOH solution = 0.0255 g.  $\text{CaCO}_3$ .

**161.** If 10 cc. of a sulphuric acid solution yield 0.1220 g.  $\text{BaSO}_4$ , how much must the solution be diluted for an exactly N/10 solution?

**162.** If 1 cc. of a potassium bichromate solution will oxidize 0.0066 g. of iron, to what volume must 100 cc. of the solution be diluted to make a N/100 solution?

**163.** Calculate the percentage of iron (Fe) in a sample of limonite from the following data:

Weight of limonite = 0.55 g.;  $\text{K}_2\text{Cr}_2\text{O}_7$  solution used = 51.1 cc.; 1 cc.  $\text{K}_2\text{Cr}_2\text{O}_7$  solution = 0.0058 g. Fe;  $\text{FeSO}_4$  solution used = 5 cc.; 5 cc. of  $\text{FeSO}_4$  solution contains 0.008 g. FeO.

**164.** A sample of iron wire is dissolved, out of contact with air, in 30 cc. of HCl, of which 1 cc. = 0.95 cc. N/2 HCl. The iron requires 40 cc. of N/10  $\text{K}_2\text{Cr}_2\text{O}_7$  for oxidation. What excess of HCl was used over that required for solution?

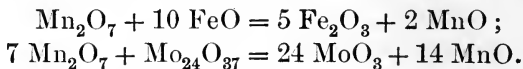
**165.** How much stannous chloride by weight will be required to reduce the iron from 0.5 g. magnetite ( $\text{FeO}$ ,  $\text{Fe}_2\text{O}_3$ ), dissolved out of contact with air?

**166.** How many cc. of HCl (sp. gr. = 1.12) are required to dissolve 0.55 g. limonite ( $2\text{Fe}_2\text{O}_3$ ,  $3\text{H}_2\text{O}$ ), assuming the only impurity to be 1.5% quartz?

**167.** If 0.75 g. of a silicate yields 0.4 g.  $\text{Fe}_2\text{O}_3$  +  $\text{Al}_2\text{O}_3$ , and the iron present requires 20 cc.  $\text{K}_2\text{Cr}_2\text{O}_7$  solution [1 cc. = 0.0784 g.  $\text{FeSO}_4(\text{NH}_4)_2\text{SO}_4$ ,  $6\text{H}_2\text{O}$ ], calculate the percentage of FeO and  $\text{Al}_2\text{O}_3$  in the sample.

**168.** What weight of iron wire containing 99.85 % Fe will react with the chromium from 0.5 g. of chromite ( $\text{FeO}$ ,  $\text{Cr}_2\text{O}_3$ )?

**169.** Calculate the value of a permanganate solution, of which 1 cc. = 0.008 g. of Fe, in terms of  $\text{MoO}_3$ .

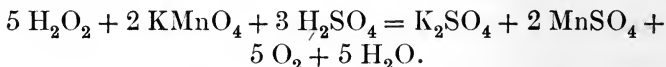


**170.** Given the following data, calculate the percentage of iron in the limonite:

Weight of limonite = 0.55 g.;  $\text{KMnO}_4$  solution used = 30 cc.; 1 cc.  $\text{KMnO}_4$  solution = 0.0084 g.  $\text{C}_2\text{H}_2\text{O}_4$ , 2  $\text{H}_2\text{O}$ .

**171.** The calcium oxalate precipitate from 0.5 g. of marble, when treated with sulphuric acid, liberates sufficient oxalic acid to reduce 43 cc. of permanganate solution (1 cc. = 0.0115 g. Fe). Calculate the percentage of calcium in the marble.

**172.** If 1 cc. of  $\text{KMnO}_4$  solution will oxidize 0.008 g. iron, calculate the equivalent of the same solution in terms of hydrogen peroxide, and also the volume of oxygen which will be evolved by each cc. of the permanganate solution during the reaction, assuming that 1 cc. of oxygen weighs 0.00143 g. under the existing conditions.



**173.** Given the following data, calculate the percentage of  $\text{MnO}_2$  in the pyrolusite:

Weight of pyrolusite = 0.48 g.; weight of  $\text{FeSO}_4$ ,  $(\text{NH}_4)_2\text{SO}_4$ , 6  $\text{H}_2\text{O}$  = 4.3501 g.;  $\text{K}_2\text{Cr}_2\text{O}_7$  solution used = 10 cc.; 1 cc.  $\text{K}_2\text{Cr}_2\text{O}_7$  solution = 0.005 g. Fe.

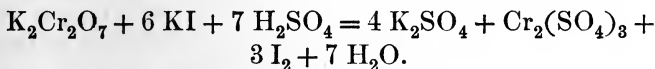
**174.** Given the following data, calculate the percentage of  $\text{MnO}_2$  in the pyrolusite:

Weight of pyrolusite = 0.48 g.; weight of iodine liberated from  $\text{KI}$  = 1.296 g.

**175.** If 1 cc. iodine solution is equivalent in oxidizing power to 0.00149 g. of  $\text{KBrO}_3$ , to what volume must 100 cc. be diluted to make a  $\text{N}/20$  solution?

**176.** Calculate the percentage purity of the sample of potassium dichromate from the following data:

Weight of sample = 0.1237 g.;  $\text{Na}_2\text{S}_2\text{O}_3$  solution used = 25 cc.; 1 cc.  $\text{Na}_2\text{S}_2\text{O}_3$  solution = 1.004 cc. iodine solution; 1 cc. iodine solution = 0.004975 g.  $\text{As}_2\text{O}_3$ .



**177.** Calculate the percentage purity of a sample of potassium iodate from the following data:

Weight of sample = 0.25 g.;  $\text{Na}_2\text{S}_2\text{O}_3$  solution used = 50 cc.; 1 cc.  $\text{Na}_2\text{S}_2\text{O}_3$  solution = 0.015 g.  $\text{I}$ .

**178.** If 1 cc. of an iodine solution has the same oxidizing power as 0.0034 g. of  $\text{KIO}_3$ , calculate its value in terms of antimony.

## CHAPTER XIII

### Review — Systematic and Miscellaneous

#### SYSTEMATIC REVIEW

1. A pressure of 1000 lb. per in.<sup>2</sup> is how many Kg. per mm.<sup>2</sup>?

2. When the mercury (sp. gr. = 13.59) barometer stands at 76 cm., how high will one of glycerine (sp. gr. = 1.27) stand?

3. When the mercury barometer stands at 760 mm., how high would one of hydrogen sulphate (sp. gr. = 1.83) stand?

4. When the barometer stands at 31 in., what is it in mm.?

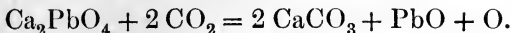
5. When the barometer stands at 755 mm., what is it in in.?

6. When the pressure of the air is 750 mm. of mercury (sp. gr. = 13.59), what is it (a) in feet of water; (b) in lb. per in.<sup>2</sup>?

7. If 200 cc. of oxygen are measured off over water at +14° C. and 756 mm., what does the dry normal gas measure?

8. How much  $\text{MnO}_2$  is required to make 10 l. of oxygen?

9. What weight and volume of oxygen at  $+15^{\circ}\text{C}$ . is obtained on passing  $\text{CO}_2$  over 1 Kg. of calcium plumbate heated to redness and then through slaked lime?



10. If 481 g. of  $\text{BaO}_2$  are heated, what volume of oxygen at  $+17^{\circ}\text{C}$ . and 800 mm. is evolved?

11. What would be the volume of the liquefied gas if the density of it is 0.89?

12. In an experiment the  $\text{CuO}$  lost 59.789 g. and 67.282 g. of water was formed. Calculate the atomic weight of oxygen.

13. What volume is occupied by 1 g. of liquid hydrogen (sp. gr. = 0.07)? If the boiling point is  $-238.5^{\circ}\text{C}$ ., what is it in  $\text{F}^{\circ}$ ?

14. A balloon holds 64  $\text{m}^3$  of hydrogen; how many Kg. does the gas weigh?

15. How many l. of hydrogen at  $+10^{\circ}\text{C}$ . and 770 mm. are obtained on passing 2 g. of steam over red-hot iron?

16. What is the mass of 1 l. of hydrogen measured over water at  $+50^{\circ}\text{C}$ . and 790 mm.?

17. What volume is occupied by 100 g. of steam measured at  $+300^{\circ}\text{C}$ .?

18. What is the volume of 1000 g. of (a) sea water (sp. gr. = 1.026); (b) ice (sp. gr. = 0.92)?

19. A block of ice (sp. gr. = 0.92) weighs 280 Kg.; find its volume.

20. If the density of ice is 0.92, what volume will 1000 cc. of water at  $+4^{\circ}\text{C}$ . occupy when frozen?

21. An iceberg floats in sea water with 30,000  $\text{m}^3$  above the sea; what is the total volume of the berg?

22. If 100 g. of gypsum are heated, what volume of steam at  $+300^{\circ}\text{C}$ . is given off?

23. If 88.88 parts of oxygen unite with 11.11 parts of hydrogen, and the equivalent of oxygen be 100, what is the equivalent of hydrogen?

24. If 500 cc. of hydrogen at  $+39^{\circ}\text{C}$ . are exploded with 500 cc. of oxygen under a pressure of 332.5 mm. what volume of which gas is left?

25. How much water must be electrolyzed to give a l. of gas at  $+15^{\circ}\text{C}$ . and 740 mm.?

26. Find the density of steam at  $+300^{\circ}\text{C}$ . referred to air at  $0^{\circ}\text{C}$ . A lb. of dry steam at  $+374^{\circ}\text{F}$ . occupies how many ft.<sup>3</sup>?

27. How many g. does a ft.<sup>3</sup> of aqueous vapor measure at  $+212^{\circ}\text{F}$ . and 30 in. of mercury weigh?

28. What do 100 l. of nitrogen weigh?

29. When 100 g. of  $\text{Pb}(\text{NO}_3)_2$  were heated, they were found by Svanberg to leave 67.4016 g. of  $\text{PbO}$ . If  $\text{O} = 100$  and  $\text{Pb} = 1294$ , what is the atomic weight of nitrogen?

30. What volume is occupied by 10,000 g. of  $\text{HNO}_3$  (sp. gr. = 1.53)?

31. What is the least quantity of  $\text{H}_2\text{SO}_4$  which can be used to decompose 500 g. of  $\text{KNO}_3$ ?

32. How much  $\text{KNO}_3$  and what volume of  $\text{H}_2\text{SO}_4$  (sp. gr. = 1.84) must be distilled together to form a l. of  $\text{HNO}_3$  (sp. gr. = 1.53)?

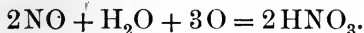
33. How many oz. of  $\text{AgNO}_3$  are formed by the action of  $\text{HNO}_3$  (sp. gr. = 1.4) upon 1000 g. of  $\text{Ag}$ ?

34. How much  $\text{NH}_4\text{NO}_3$  is required to make 40 l. of  $\text{N}_2\text{O}$ ?

35. What volume of hydrogen is required to combine with the oxygen contained in 10 g. of nitrous oxide?

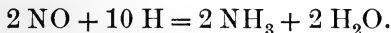
36. What volume of NO at  $+13^{\circ}\text{C}$ . is obtained on dissolving 25 g. of Cu in  $\text{HNO}_3$ ?

37. What volume of oxygen is required to convert 10 g. of NO in presence of water into  $\text{HNO}_3$ ?

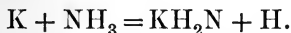


38. How many g. of  $\text{NH}_3$  can be obtained from 2140 g. of  $\text{NH}_4\text{Cl}$ ?

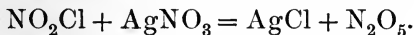
39. How many g. of  $\text{NH}_3$  are obtained on passing 3 g. of NO, mixed with excess of H, over hot spongy Pt?



40. If 2 g. of potassium are heated in  $\text{NH}_3$ , how much potassiumamide and what volume of H at  $+15^{\circ}\text{C}$ . are formed?



41. If 2 l. of nitrosyl chloride at  $+15^{\circ}\text{C}$ . are passed over warm  $\text{AgNO}_3$ , how much  $\text{N}_2\text{O}_5$  is formed?



42. If 100 l. of air are passed over red-hot Cu, how much does the Cu increase in mass?

43. If 20 cc. of air are mixed with 30 cc. of H and exploded, what volumes of what gases are left?

44. What is the difference in mass between 10 l. of air at  $+15^{\circ}\text{C}$ . and 10 l. of N under 775.62 mm.?

45. A man inhales 18 ft.<sup>3</sup> of air per hour. How many lb. of O does he require in 24 hr.?

46. What is the mass of 500 m.<sup>3</sup> of air at  $+21^{\circ}\text{C}$ .?

47. An inch of rainfall is how many tons of water per acre?

48. How much moist iron can be oxidized by 1000 l. of air at  $+13^{\circ}\text{C}.$ ?

49. How much S can be burned in 20 l. of air at  $+26^{\circ}\text{C}.$ ?

50. What volume of air at  $+21^{\circ}\text{C}.$  must be passed over 100 g. of Cu to convert it into CuO?

51. How much Mg can be burned in a globe containing 5 l. of air at  $+21^{\circ}\text{C}.$  and 744 mm.?

52. A cubic mile of air at 760 mm. and  $+30^{\circ}\text{C}.$  is saturated with water vapor. How many tons of rain will fall if the temperature sinks to  $0^{\circ}\text{C}.$ ?

53. In one of Lord Rayleigh's experiments, 7925 cc. of air left 65 cc. of argon; what is the percentage by volume of argon in the atmosphere?

54. The specific heat of graphite is 0.202; what is its probable atomic weight?

55. If 4427 million  $\text{ft.}^3$  of coal are piled into a cube, find the length of each edge in m.

56. Find the formula of a substance containing: C, 20 %; O, 26.6 %; S, 53.3 %.

57. What volume of air is required to burn a Kg. of carbon?

58. If 15.2 l. of methane at  $+17^{\circ}\text{C}.$  and 870 mm. are required, how much dry sodium acetate must be used?

59. If 25 cc. of ethene are exploded with 100 cc. of O, what volume of  $\text{CO}_2$  is formed and of O is left?

60. What volume of cyanogen at  $+16^{\circ}\text{C}.$  is given off on heating 5 g. of  $\text{Hg}(\text{CN})_2$ ?



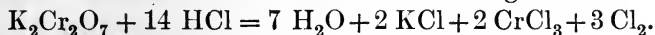
61. Find the mass of 295 cc. of camphor ( $C_{10}H_{16}O$ ) vapor at  $+210^{\circ}C$ .

62. In Meyer's third method, 0.12 g. of dibromamylene gave 13.1 cc. of air at  $+17^{\circ}C$ . and 758 mm. Find the density of the vapor.

63. How many g. of  $MnO_2$  are required to make 40 l. of Cl at  $+37^{\circ}C$ .?

64. What volume of Cl at  $+12^{\circ}C$ . and 750 mm. can be obtained from 1170 g. of salt?

65. If 10 g. of  $K_2Cr_2O_7$  are heated with HCl, what volume of Cl at  $+30^{\circ}C$ . and 740 mm. is given off?



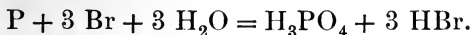
66. What volume of Cl will diffuse under the same conditions as 10 cc. of N?

67. When 1 g. of bleaching powder was boiled with CuO, it gave 80 cc. of O at  $+7^{\circ}C$ . and 800 mm. Find the percentage of real bleaching powder in the sample.

68. What is the mass of 1 l. of chloroform vapor measured at  $+200^{\circ}C$ .?

69. How many cc. does a lb. of Br (sp. gr. = 3.19) occupy?

70. How much P and what volume of Br is required to make 1 l. of HBr?



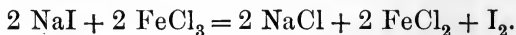
71. Br vapor is 2.8 times as heavy as air; what is its molecular weight?

72. If 10 g. of  $KBrO_3$  are heated, what volume of oxygen measured at  $+13^{\circ}C$ . is given off?

73. A spherical glass bulb contains 10 g. of liquid Br (sp. gr. = 3.19); what must the internal radius be?

## 170 PROGRESSIVE PROBLEMS IN CHEMISTRY

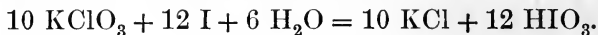
74. How much  $\text{FeCl}_3$  is required to obtain iodine from 100 tons of kelp, each ton of which contains 4.07 Kg. of iodine?



75. How many times is solid iodine (sp. gr. = 4.94) as heavy as an equal volume of its vapor measured at + 350° C.?

76. How much iodine is there in a l. of a solution (sp. gr. = 1.7) containing 52 % of HI?

77. How much iodine and  $\text{KClO}_3$  are required to make 1 Kg. of hydrogen iodate?



78. If 8 g. of silver iodate are heated, what volume of oxygen at + 18° C. and 720 mm. is evolved?

79. What volume of HF at + 39° C. can be obtained from 50 g. of NaF?

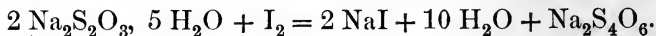
80. Find the mass of 10 l. of HF at + 30° C. and 740 mm.

81. What volume is occupied by 1000 g. of (a) common sulphur (sp. gr. = 2.05), (b) plastic sulphur (sp. gr. = 1.95)?

82. What volume is occupied by 19.2 g. of  $\text{SO}_2$ ?

83. If 16 cc. of H diffuse in 100 sec., what volume of  $\text{SO}_2$  will diffuse under the same conditions?

84. How much iodine is needed to oxidize 1 g. of "hypo," and how much sodium tetrathionate is formed?



85.  $\text{SO}_3$  is passed over 187 g. of BaO in a heated tube; how much  $\text{BaSO}_4$  is formed?

86. How many Kg. of  $\text{H}_2\text{SO}_4$  (sp. gr. = 1.84) will a tank 1 m.  $\times$  2 m.  $\times$  3 m. hold?

87. If 100 g. of Pb form 146.45 g. of  $\text{PbSO}_4$ , what is the molecular weight of  $\text{H}_2\text{SO}_4$ ?

88. If 20 g. of S are heated in H, what volume of  $\text{H}_2\text{S}$  at  $+30^\circ\text{C}$ . is formed?

89. If 390 g. of  $\text{Sb}_2\text{S}_3$  are dissolved in hot HCl, what volume of  $\text{H}_2\text{S}$  at  $+30^\circ\text{C}$ . is given off?

90. How many g. of S are there in 600 cc. of  $\text{H}_2\text{S}$ ?

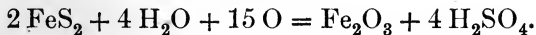
91. What volume of  $\text{H}_2\text{S}$  will diffuse under the same conditions as 10 cc. of oxygen?

92. How much PbS and HgS can be thrown down by 500 cc. of  $\text{H}_2\text{S}$  at  $+14^\circ\text{C}$ .?

93. What volume of  $\text{CS}_2$  (sp. gr. = 1.26) can be made by the action of a Kg. of S upon hot charcoal?

94. What is the mass of 4 l. of carbon oxysulphide ( $\text{COS}$ ) at  $+30^\circ\text{C}$ .?

95. To make 1000 Kg. of  $\text{H}_2\text{SO}_4$ , how much pyrite is needed? What volume of air at  $+15^\circ\text{C}$ . and of steam at  $+300^\circ\text{C}$ . are required?

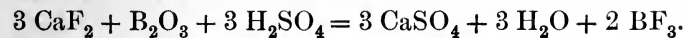


96. What volume of  $\text{CS}_2$  (sp. gr. = 1.26) must be burned to give 10 l. of  $\text{SO}_2$  at  $+15^\circ\text{C}$ . and 750 mm.?

97. Boron trichloride is 4.07 times as heavy as air; what is its molecular weight?

98. How many g. do 200 cc. of  $\text{BCl}_3$  at  $+97^\circ\text{C}$ . and 720 mm. weigh?

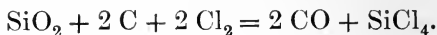
99. If 90 g. of  $\text{CaF}_2$  are heated with  $\text{B}_2\text{O}_3$  and  $\text{H}_2\text{SO}_4$ , what volume of  $\text{BF}_3$  at  $+15^\circ\text{C}$ . is formed?



100. How much Si can be obtained from 119 g. of  $K_2SiF_6$ ?  $K_2SiF_6 + 4 K = 6 KF + Si$ .

101. How much silica is formed on burning 2 l. of  $SiH_4$ ?

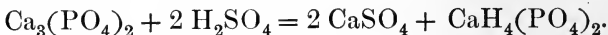
102. What volume of Cl. at  $+26^\circ C$ . and mass of C are required to make 100 g. of  $SiCl_4$ ?



103. How much does a l. of  $SiCl_4$  at  $+200^\circ C$ . weigh?

104. Find the mass in g. of a sphere of quartz (sp. gr. = 2.65) 1 dm. in diameter.

105. How much bone ash containing 87% of  $Ca_3(PO_4)_2$  is required to make 200 Kg. of superphosphate of lime?



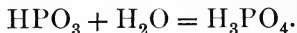
106. If 100 l. of yellow (sp. gr. = 1.83) are converted into red (sp. gr. = 2.16) phosphorus, what is the volume of the latter variety?

107. What is the mass of 1.234 l. of P vapor ( $P_4$ ) at  $+500^\circ C$ .?

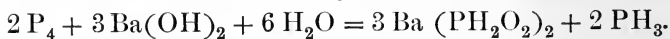
108. If 1 g. of P, when burned, gives 2.29 g. of  $P_2O_5$ , what is the atomic weight of P?

109. Find the formula of a substance containing: Ca, 38.72%; P, 20%; O, 41.28%.

110. If 20 g. of hydrogen metaphosphate are boiled with water, how much orthophosphate is formed?



111. If 5 g. of phosphorus are boiled with baryta water, what volume of  $PH_3$  at  $+15^\circ C$ . is given off?



**112.** What volume of  $\text{PH}_3$  will diffuse under the same conditions as 100 cc. of hydrogen?

**113.** What volume of  $\text{Cl}$  at  $+20^\circ \text{C.}$  must be passed into 1 Kg. of melted  $\text{P}$  to convert it into  $\text{PCl}_3$ ?

**114.** How much  $\text{P}$  is contained in 4.3 l. of  $\text{PH}_3$  measured at  $+22^\circ \text{C.}$  and 730 mm.?

**115.** How many g. do 2 l. of  $\text{As}_4$  vapor weigh?

**116.** If 743 cc. of gas are heated from  $+47^\circ \text{C.}$  to  $+83^\circ \text{C.}$ , what is the new volume?

**117.** What volume do 486 cc. of gas under a pressure of 760 mm. occupy under the pressure of 3 ft. of mercury?

**118.** If 1000 cc. of air at  $-31.2^\circ \text{R.}$  are heated to  $+172.4^\circ \text{F.}$ , what is the new volume?

**119.** If 546 cc. of gas at  $+17^\circ \text{C.}$  and 760 mm. are cooled to  $0^\circ \text{C.}$ , the pressure being decreased to 600 mm., what is the new volume?

**120.** If 1234 cc. of normal gas are cooled to  $-52^\circ \text{C.}$ , the pressure being decreased to 617 mm., what is the new volume?

**121.** A few drops of water at  $+15^\circ \text{C.}$  are passed up into a barometer standing at 30 in. How high does the mercury stand?

**122.** If 100 g. of  $\text{Sb}$  gave 124.8 g. of  $\text{Sb}_2\text{O}_4$ , and if  $\text{O} = 100$ , what is the atomic weight of  $\text{Sb}$ ?

**123.**  $\text{Bi}$  melts at  $+264^\circ \text{C.}$ ; what temperature is this on the  $\text{F.}$  and  $\text{R.}$  scales?

**124.** Schneider found that 54.969 g. of  $\text{Bi}$  formed 61.311 g. of the trioxide; what is the atomic weight of  $\text{Bi}$ ?

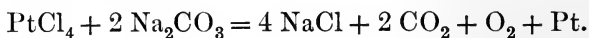
125. What volume is occupied by 10 g. of trimethylstibine  $\text{Sb}(\text{CH}_3)_3$  at  $+300^\circ \text{C}.$ ?

126. What is the mass of a sphere of Bi (sp. gr. = 9.9) 2 mm. in diameter?

127. Find the volume of 100 g. of (a) Pt (sp. gr. = 21.5); (b) Au (sp. gr. = 19.3); (c) Pb (sp. gr. = 11.4); (d) Li (sp. gr. = 0.59).

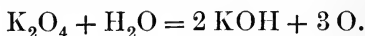
128. What length of wire 2 mm. in diameter can be drawn from 1 dm.<sup>3</sup> of metal?

129. How much platinum black is obtained on boiling 40 g. of platinic chloride with grape sugar and sodium carbonate?

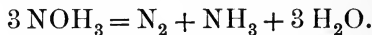


130. If 900 g. of Au (sp. gr. = 19.3) are fused with 100 g. of Ag (sp. gr. = 10.5), what is the density of the alloy?

131. If 5 g. of  $\text{K}_2\text{O}_4$  are boiled with water, what volume of O at  $+100^\circ \text{C}.$  is evolved?



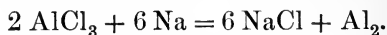
132. If 2 g. of hydroxylamine are heated with KOH, what volumes of N and of  $\text{NH}_3$  at  $+21^\circ \text{C}.$  are formed?



133. How much SrO is obtained on heating 1000 g. of  $\text{Sr}(\text{NO}_3)_2$ ?

134. One g. of  $\text{CaSO}_4$  will form how much  $\text{BaSO}_4$ ?

135. How much Al is set free on passing 7.339 l. of the vapor of  $\text{AlCl}_3$  at  $+546^\circ \text{C}.$  over heated Na?

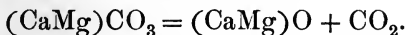


136. How much sulphide is formed on heating 5 g. of Al in S vapor?

137. If 20 g. of cryolite are heated with  $\text{H}_2\text{SO}_4$ , what volume of HF at  $+20^\circ \text{C}$ . is given off?



138. If 4 g. of dolomite, when strongly heated, gave 937.4 cc. of  $\text{CO}_2$ , what is the percentage of Ca and  $\text{MgCO}_3$  in the dolomite?

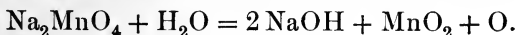


139. What volume of N at  $+20^\circ \text{C}$ . and 780 mm. will combine with 50 g. of Mg?

140. How much zinc white can be made from 1000 g. of Zn and what volume of air is required?

141. Brass consists of 2 parts of Cu alloyed with 1 part of Zn; find the approximate formula for it.

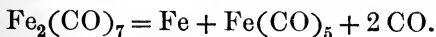
142. If 100 g. of sodium manganate are heated in steam, what volume of oxygen at  $+13^\circ \text{C}$ . is set free?



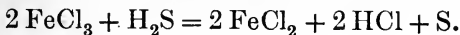
143. During the solution of 1 g. of iron, 389.74 cc. of H at  $+14^\circ \text{C}$ . and 820 mm. were evolved; find the equivalent of iron.

144. According to Berzelius, 1.586 g. of Fe form 2.265 g. ferric oxide; what is the atomic weight of iron?

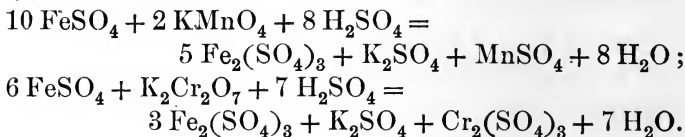
145. What volume of CO at  $+17^\circ \text{C}$ . is set free on heating 10 g. of di-ferroheptacarbonyl to  $+80^\circ \text{C}$ .?



146. How much S precipitates on passing 1.7 l. of  $\text{H}_2\text{S}$  at  $+17^\circ \text{C}$ . through a solution of  $\text{FeCl}_3$ ?

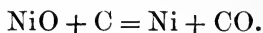


147. How much Fe is converted from a ferrous to a ferric salt by 1 g. of potassium (a) permanganate; (b) dichromate?

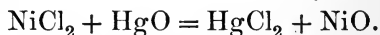


148. If 3 g. of  $\text{KMnO}_4$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  are each dissolved in 1 l. of water, to how much Fe is 1 cc. of each solution equivalent?

149. What volume of CO at  $+1200^\circ \text{C}$ . is set free in reducing 764 g. of nickelous oxide?



150. How much  $\text{HgO}$  is required to precipitate 20 g. of Ni as  $\text{NiO}$ ?



151. What is the formula of a substance containing: Ni, 31.15 %; H, 3.18 %; N, 14.84 %; S, 16.95 %; O, 33.88 %?

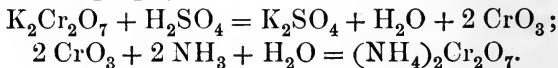
152. What volume of H at  $+15^\circ \text{C}$ . is required to reduce 100 g. of  $\text{Co}_2\text{O}_3$ ?

153. If 100 g. of  $\text{Hg}_2\text{CrO}_4$  are heated, how much  $\text{Cr}_2\text{O}_3$  is formed and what volume of O is given off?



154. According to Siewert, 36.865 parts of  $\text{CrCl}_3$  give 100 parts  $\text{AgCl}$ ; find the atomic weight of chromium.

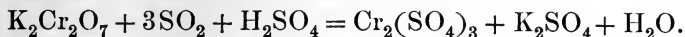
155. How much  $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$  can be made from 1000 g. of  $\text{K}_2\text{Cr}_2\text{O}_7$ ?





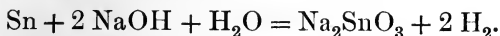
156. According to Berlin, 100 g. of  $\text{Pb}(\text{NO}_3)_2$  gave 97.576 g. of  $\text{PbCrO}_4$ ; find the atomic weight of chromium.

157. What volume of  $\text{SO}_2$  at  $+15^\circ \text{C}$ . and 780 mm. is required to reduce 47 g. of  $\text{K}_2\text{Cr}_2\text{O}_7$ ?



158. How many times is the vapor of chromyl dichloride ( $\text{CrO}_2\text{Cl}_2$ ) as heavy as air?

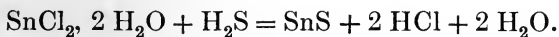
159. If 17 g. of Sn were dissolved in NaOH, what volume of H at  $+15^\circ \text{C}$ . was evolved?



160. What volume of HCl at  $+60^\circ \text{C}$ . is required to convert 50 g. of Sn into stannous chloride?

161. What volume of Cl at  $+26^\circ \text{C}$ . is absorbed in converting 1000 g. of Sn into the tetrachloride?

162. What volume of  $\text{H}_2\text{S}$  at  $+26^\circ \text{C}$ . is required to throw down the Sn from a solution of 110 g. of "tin salts"?



163. If 9 g. of Sn are dissolved in aqua regia, what volume of  $\text{H}_2\text{S}$  at  $+15^\circ \text{C}$ . and 770 mm. is required to precipitate them?

164. If 4 g. of Sn are heated in 200 cc. of  $\text{H}_2\text{S}$  at  $+10^\circ \text{C}$ . and 744 mm., how much does the Sn increase in mass?

165. What volume of air is required to convert 37.1 Kg. of Pb into litharge?

166. How much silica must be fused with 1000 g. of PbO to form lead silicate?

167. What volume of O at  $+13^{\circ}$  C. is absorbed in forming 1000 g. of red lead?

168. According to Dumas, 100 g. of minium when heated give 2.4 g. of O; find its formula.

169. Find the percentage composition of realgar, orpiment, and arsenic pentasulphide.

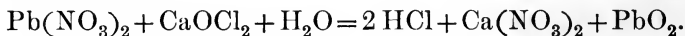
170. What volume of  $\text{H}_2\text{S}$  at  $+21^{\circ}$  C. is required to precipitate the As from a solution of 100 g. of  $\text{As}_2\text{O}_3$ ?

171. The specific heat of As is 0.0814 and 96.15 parts of As combine with 3.85 parts of H; find the atomic weight of the element.

172. How much Sb is there in 1020 Kg. of the trisulphide?

173. What volume is occupied by 100 g. of (a) As (sp. gr. = 5.8); (b) Sb (sp. gr. = 6.8); (c) Bi (sp. gr. = 9.9)?

174. How much lead dioxide can be made from 20 g. of  $\text{Pb}(\text{NO}_3)_2$ ?



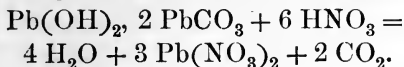
175. Find the formula of Cassel yellow, which contains: Pb, 90.05 %; Cl, 3.86 %; and O, 6.09 %.

176.  $\text{PbI}_2$  is soluble in 190 times its mass of hot water. How much KI and  $\text{Pb}(\text{NO}_3)_2$  must be dissolved in 250 cc. of water that the precipitate may redissolve on boiling?

177. According to Stas, 100 g. of Pb form 195.9703 g. of  $\text{Pb}(\text{NO}_3)_2$ ; what is the atomic weight of Pb?

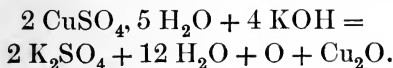
178. A substance contains of lead monoxide 76.69 % and of chromium trioxide 23.31 %; find its formula.

**179.** What volume of  $\text{CO}_2$  at  $+26^\circ \text{C}$ . is evolved on dissolving 487 g. of white lead in hydrogen nitrate?

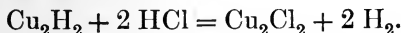


**180.** What volume is occupied by the vapor of 4 g. plumbic ethide,  $\text{Pb(C}_2\text{H}_5)_4$ , measured at  $+300^\circ \text{C}$ . and 740 mm.?

**181.** If 100 g. of  $\text{CuSO}_4$  are warmed with  $\text{KOH}$  and grape sugar, how much cuprous oxide precipitates?



**182.** What volume of  $\text{H}$  at  $+100^\circ \text{C}$ . and 746 mm. is given off on dissolving 3 g. of cuprous hydride in  $\text{HCl}$ ?



**183.** If 8000 g. of cinnabar are roasted, how much  $\text{Hg}$  and what volume of  $\text{SO}_2$  at  $+13^\circ \text{C}$ . are formed?

**184.**  $\text{Hg}$  vapor is 6.976 times as heavy as air; find its density referred to  $\text{H}$ .

**185.** When 1 Kg of  $\text{Hg}$  at  $+100^\circ \text{C}$ . is mixed with 1 Kg of water at  $+10^\circ \text{C}$ ., the temperature of the mixture was found to be  $+13^\circ \text{C}$ .; what is the specific heat of  $\text{Hg}$ ?

**186.** Find the formula of a cadmium amalgam which contains:  $\text{Hg}$ , 78.26 %, and  $\text{Cd}$ , 21.74 %.

**187.** Excess of  $\text{Hg}$  is heated in 10 l. of air measured at  $+14^\circ \text{C}$ .; how much  $\text{HgO}$  is formed?

**188.** The vapor of  $\text{Hg}_2\text{Cl}_2$  is 8.21 times as heavy as air; what is its apparent molecular weight?

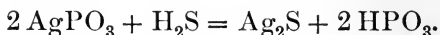
**189.** How many g. do 500 cc. of the vapor of corrosive sublimate at  $+350^\circ \text{C}$ . weigh?

190. How much Fe and Hg are required to reduce 48 lb. of AgCl?

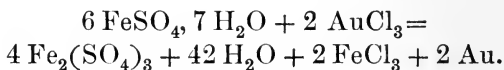
191. Melted Ag dissolves 22 times its volume of oxygen at  $0^{\circ}$  C. What volume of O at  $+13^{\circ}$  C. would be given off by 1 Kg. of Ag (sp. gr. = 10.5) on cooling?

192. According to Stas, 53.1958 g. of Ag form 92.6042 g. of AgBr; what is the atomic weight of silver?

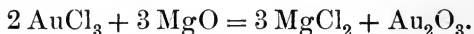
193. What volume of  $\text{H}_2\text{S}$  at  $+27^{\circ}$  C. and 570 mm. is required to precipitate the Ag from 100 g. of silver metaphosphate?



194. How much  $\text{FeSO}_4$  is required to precipitate 100 g. of Au?



195. How much magnesia is required to throw down 10 g. of auric oxide?



196. What volume of O is given off on heating 4.412 g. of  $\text{Au}_2\text{O}_3$ ?

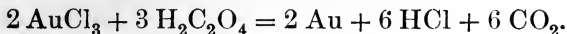
197. Prat has described an oxide of gold containing 7.7 % of oxygen; find its formula.

198. How much aurous bromide can be made from 2 g. of  $\text{Au}_2\text{O}$ ?

199. If 50 g. of auric chloride are heated to  $+170^{\circ}$  C., how much aurous chloride and what volume of Cl measured at  $+21^{\circ}$  C. are formed?



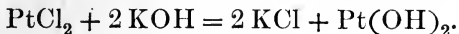
200. A solution of 10 g. of  $\text{AuCl}_3$  is mixed with hydrogen oxalate; how much Au precipitates and what volume of  $\text{CO}_2$  at  $+13^\circ \text{C}$ . is given off?



201. How much spongy platinum is left on heating 100 g.  $(\text{NH}_4)_2\text{PtCl}_6$ ?

202. How much  $\text{PtCl}_4$  is obtained on dissolving 500 g. of Pt in aqua regia?

203. How much platinous hydrate is formed on digesting 200 g. of platinous chloride with KOH?



204. According to Berzelius, 10 g. of Pt form 24.735 g. of  $\text{K}_2\text{PtCl}_6$ ; find the atomic weight of platinum.

#### MISCELLANEOUS REVIEW

205. How much CaO and how much coke are needed to produce 100 lb. of  $\text{CaC}_2$ ?

206. How much chrome-alum could be made from 10 Kg. of chromite?

207. What weight of chrome-yellow would be formed if a solution containing 430 g. of  $\text{K}_2\text{CrO}_4$  were precipitated with lead acetate?

208. What weight of  $\text{KMnO}_4$  could be prepared from 10 Kg. of an ore containing 62% pyrolusite?

209. Find the percentage composition of nitric acid. How many g. of each component in 150 g. of nitric acid?

210. Find the percentage composition of  $\text{H}_2\text{SO}_4$ . How many g. of HCl can be formed by the action of 490 g. of  $\text{H}_2\text{SO}_4$  on NaCl?

**211.** Find the percentage composition of  $\text{H}_2\text{S}$ . How many g. of  $\text{H}_2\text{S}$  can be made by the action of 146 g. of  $\text{HCl}$  on ferrous sulphide?

**212.** A mixture of 30 cc. of air and 40 cc. of hydrogen is introduced into a eudiometer tube and the mixture ignited by an electric spark. The gas remaining in the tube after the explosion measures 51.1 cc. What per cent. by volume of oxygen is contained in the air used, assuming that the gases are all measured at the same temperature?

**213.** A candle of paraffine (C, 85 % ; H, 15 %) loses 90 g. in weight by burning; find the weights and volumes of the products of combustion and of oxygen used.

**214.** What weight of phosphorus would be needed to combine with 700 cc. of oxygen to form phosphorus pentoxide?

**215.** If 1 g. of hydrogen and 1 g. of oxygen are mixed and the mixture is ignited, what weight of water will be formed and what volume of gas will remain uncombined?

**216.** What weight of oxygen will unite to form water with a volume of hydrogen that measures 1250 cc. at 740 mm. and  $+18^\circ \text{C}.$ ?

**217.** A certain analysis gives 42.1% of carbon, 7.1 % of hydrogen, 56.2% of oxygen. (a) Find a formula for the compound. (b) It being hexabasic, give the true formula. (c) All the hydrogen can be replaced by a metal. To what class of compounds does it belong?

**218.** Reduce the following to the Fahrenheit scale : (a)  $+35^\circ \text{C}.$  ; (b)  $+89^\circ \text{C}.$  ; (c)  $-40^\circ \text{C}.$  ; (d)  $-50^\circ \text{C}.$  ; (e)  $+104^\circ \text{C}.$

219. If a given weight of gas occupies 1.1 l. at  $0^{\circ}\text{C}$ . and 380 mm., what volume should it occupy at  $+273^{\circ}\text{C}$ . and 760 mm.?

220. Reduce the following to  $\text{ft.}^3$  or  $\text{in.}^3$ : (a) 1.5 l.; (b) 760 cc.; (c)  $7\text{ m.}^3$ ; (d)  $85\text{ dm.}^3$ ; (e) 900 cc.; (f) 1.2 cc.

221. If water absorbs 1000 times its volume of ammonia, how many g. of ammonium chloride will furnish enough gas for 2 l. of water?

222. How many g. of coin silver, which is  $\frac{9}{10}$  pure, will make 50 g. of bromide of silver for photography?

223. Prove that the phosphorus molecule has 4 atoms.

224. A  $\text{m.}^3$  of carbon monoxide burns in air. (a) Find the number of cc. of carbon dioxide which will form at N.T.P. (b) Find approximately the number of  $\text{ft.}^3$

225. A cube of sulphur (sp. gr. = 2) is  $2\frac{1}{2}$  cm. on a side; how much  $\text{SO}_2$ , by weight and by volume, will form on burning it?

226. By using 100 tons of  $\text{FeS}_2$  there were obtained 136.3 tons of  $\text{H}_2\text{SO}_4$ . If there were no waste, what per cent. of sulphur does the pyrite carry? What per cent. does pure  $\text{FeS}_2$  carry?

227. A mixture of  $\frac{2}{3}$  hydrogen by volume and  $\frac{1}{3}$  arsine, 5 l. in all, is burned. (a) What weight of water is formed? (b) What volume would the arsenic occupy at  $+273^{\circ}\text{C}$ . if it could be set free as a gas?

228.  $\text{H}_2\text{SO}_4$  has sp. gr. = 1.84; what volume of sulphur dioxide at  $+200^{\circ}\text{C}$ . and 700 mm. will be given by 30 cc. of it reduced by copper?

229. What volume of hydrogen is required to combine with the oxygen in 12 g. of nitrous oxide?

230. Water will absorb 1050 times its volume of ammonia gas; how many g. of ammonium chloride will be required to furnish the gas sufficient to saturate 500 cc. of water?

231. If 10 l. of hydrogen diffuse through a certain apparatus in a certain time, what volume of hydrogen phosphide will diffuse under similar conditions?

232. Compute the vapor density (*a*) of ozone from the atomic weight of oxygen and the fact of there being 3 atoms in the molecule of ozone; (*b*) of arsenic with 4 atoms per molecule; (*c*) of zinc, which has 1 atom per molecule.

233. A block of lead (sp. gr. = 11.4)  $5 \times 2 \times 2$  cm. is dissolved by  $\text{HNO}_3$ ; how much NO by volume ought to be liberated?

234. How much  $\text{CaCO}_3$  by weight should be formed by introducing into lime water the carbon dioxide formed in burning 500 cc. of liquid ether having sp. gr. = 0.72?

235. How much phosphorus by weight can be burned in 5 l. of nitrogen monoxide?

236. How much  $\text{H}_2\text{S}$  by volume will be formed by the action on FeS of 1 l. of HCl solution which has sp. gr. = 1.2 and contains 43% HCl gas?

237. A substance analyzed gives 20% water, 26.66% carbon, 53.13% oxygen; find its formula.

238. How much chlorine in a l. of water, 20 cc. of which will precipitate all the silver in 0.02 g. of silver nitrate?



**239.** If 2 Kg. of coal produce in burning 6 Kg. of  $\text{CO}_2$  and 900 g. of water, what percentage of carbon and of hydrogen does the coal contain?

**240.** One g. of an aqueous solution of hydrogen chloride (sp. gr. = 1.20) contains how many cc. of hydrogen chloride?

**241.** How many Kg. in 3 m.<sup>3</sup> of sulphuric acid (sp. gr. = 1.84)?

**242.** What volume would be occupied by 2 cc. of sulphuric ether (sp. gr. = 0.72) if it were vaporized at + 270° C. and 750 mm.?

**243.** Reduce the following to C.<sup>o</sup>: (a) + 38° F.; (b) + 120° F.; (c) - 64° F.; (d) - 30° F.; (e) 0° F.; (f) - 40° F.

**244.** If equal volumes of hydrogen and oxygen are mixed in a closed space at a temperature above the boiling point of water, and the mixture is exploded, what will be the pressure of the products compared with the original pressure at the same temperature?

**245.** When 37.4 g. of nickel oxide were heated in a current of hydrogen they lost in weight 8.000 g. The specific heat of nickel is 0.109. What information do these data give concerning the atomic weight of nickel?

**246.** Write the equations representing the volume relations, (a) when carbon monoxide burns in oxygen; (b) when ammonia gas is decomposed into its elements. Give the relative numbers of molecules taking part in each reaction.

**247.** What volume is occupied by 80 g. of ammonia (a) at N.T.P.; (b) at + 273° C. and pressure of 2 atmospheres?

**248.** How much ammonium chloride must be heated with lime to make 50 l. of ammonia at N.T.P.?

**249.** Write equations for (a) the action which takes place on boiling water hardened by carbonate of magnesium in solution; (b) the preparation of peroxide of hydrogen; (c) the action of carbonic acid on barium hydrate.

**250.** How much zinc sulphate can be made from 20 lb. of zinc?

**251.** If 3 l. of a gas consisting of carbon and oxygen weigh 3.78 g., what is the formula of the gas?

**252.** Compare the diffusibilities of these gases, carrying the answer to one decimal place: (a)  $\text{N}_2\text{O}$  and  $\text{CO}$ ; (b)  $\text{Br}$  and  $\text{Cl}$ ; (c)  $\text{N}$  and  $\text{NH}_3$ ; (d)  $\text{NO}$  and  $\text{H}$ ; (e)  $\text{CO}$  and  $\text{CO}_2$ ; (f)  $\text{CH}_4$  and  $\text{HCl}$ ; (g)  $\text{C}_2\text{H}_6\text{O}$  and  $(\text{C}_2\text{H}_5)_2\text{O}$ ; (h)  $\text{H}_2\text{S}$  and  $\text{CS}_2$ ; (i)  $\text{H}$  and  $\text{H}_2\text{S}$ .

**253.** A gas,  $A$ , diffuses 3.5 times faster than  $B$ ; if the molecular weight of  $A$  is 4, what is that of  $B$ ?

**254.** Two gases,  $A$  and  $B$ , diffuse approximately at 6.1:4.1; if  $A$  has a molecular weight of 34, what should be that of  $B$ ?

**255.** If 3 l. of nitrous oxide weigh 5.94 g., what is its vapor density?

**256.** What is the weight of 1239 l. of phosphorus vapor at  $+21^\circ \text{C}$ .?

**257.** A manufacturer prepares phosphorus from 169 tons of bones, containing 55% of calcium phosphate; how much phosphorus should he obtain and how much oil of vitriol ought he to use?

**258.** How much chlorine by volume can be got from 10 g. of  $\text{NaCl}$ ?

**259.** If 5 l. of turpentine vapor are burned in air, (a) what are the products; (b) what is the volume of the compound of carbon formed at  $0^{\circ}$  C. and 760 mm.?

**260.** Excess of carbon is thrown into 100 g. of fused niter; what volume of N and of  $\text{CO}_2$  is evolved?



**261.** If the density of marsh gas is 0.55 and its percentage composition is carbon, 74.95, and hydrogen, 25.05, prove that the atomic weight of carbon is not more than 12.

**262.** Prove that the molecule of oxygen has at least 2 atoms.

**263.** How many cc. of liquid water are contained in a rectangular piece of gypsum (sp. gr. = 2.3) which is 3 cm.  $\times$  5 cm.  $\times$  7 cm.? How much  $\text{SO}_2$  is contained in it?

**264.** When 7 cc. of sulphur vapor and 5 cc. of oxygen combine, so far as possible, to form  $\text{SO}_2$ , how many cc. of  $\text{SO}_2$  are formed and how much of either factor is left?

**265.** A cube of crystallized  $\text{NaCO}_3 \cdot 10 \text{H}_2\text{O}$  (sp. gr. = 1.45) is 6 cm. on a side. (a) What volume, as a liquid, would the water of crystallization occupy? (b) What volume would the gaseous  $\text{CO}_2$  obtainable from the salt at N.T.P. occupy?

**266.** (a) How much sulphur by weight is required to make 1000 g. of  $\text{H}_2\text{SO}_4$ ? (b) If the sp. gr. of  $\text{H}_2\text{SO}_4$  is 1.84, how many l. would the acid occupy?

**267.** How much  $\text{SO}_2$  by volume could be obtained by acting with  $\text{H}_2\text{SO}_4$  on a plate of copper (sp. gr. = 8.85) which is 5 cm.  $\times$  8 cm.  $\times$  10 cm.?

**268.** A certain volume of gas at 740 mm. and  $+30^{\circ}\text{C}$ . weighs 5 g.; what would an equal volume of the same gas weigh at 760 mm. and  $0^{\circ}\text{C}$ .?

**269.** Of two gases, *A* and *B*, *A* diffuses twice as rapidly as *B*; compare their molecular weights.

**270.** Uranium is the metal having the greatest atomic weight, 238.5; compute its specific heat from the atomic heat.

<b>271. GASEOUS COMPOUNDS</b>	<b>ANALYSES</b>	<b>SP. GR.</b>
HX	H : X = 1 : 3	0.557
OX	O : X = 8 : 3	1.529
HNX	H : N : X = 2 : 28 : 24	0.948

In the above table we have gaseous compounds of an element X. The analyses of the compounds are given, also the sp. gr., air being unity. Air is 14.4 as heavy as hydrogen. What is the atomic weight of the element X? Give reasons.

**272.** How many l. of HCl at  $+273^{\circ}\text{C}$ . and 760 mm. could be obtained by treating with  $\text{H}_2\text{SO}_4$  a cube of rock salt (sp. gr. = 2.13) which measures 5.5 cm. on a side?

**273.** How many l. of hydrogen would be needed to combine with all the oxygen in 50 g. of mercuric oxide?

**274.** If 4 l. of hydrogen diffuse through an apparatus in 10 minutes, and 1 l. of oxygen in an equal time under similar conditions, what is the density of oxygen?

**275.** (a) How many cc. of oxygen at  $+33^{\circ}\text{C}$ . are needed to burn 175 cc. of benzene vapor? (b) What would be formed? (c) What weight of  $\text{CO}_2$ ?

**276.** I wish to make 30 g. of potassium chloride; how much potassium chlorate ought I to take?

**277.** Assume that in burning all 2240 lb. of a certain soft coal in gas retorts, 6 lb. of ammonia gas are liberated and collected in the ammoniacal liquor; that 5 % is lost in the transportation and working of the liquor; that it is made into ammonium sulphate. How much dry sulphate of ammonium will it yield, and how much pure sulphuric acid will be used in the operation, assuming no waste of acid?

**278.** What volume at  $+20^{\circ}\text{C}$ . and under a pressure of 2 atmospheres will 100 l. of sulphur dioxide, measured at  $0^{\circ}\text{C}$ . and under a pressure of 1 atmosphere, occupy? What weight of sulphur is necessary to produce this amount of sulphur dioxide?

**279.** If the combustion of 1 g. of sulphur to sulphur dioxide develops 2220 calories, what is the heat of combustion of sulphur?

**280.** Calculate the number of  $\text{m}^3$  of air at  $+20^{\circ}\text{C}$ . needed for one Kg. of coal, the composition of which is: carbon, 76.81 %; hydrogen, 5.14 %; oxygen, 7.90 %; nitrogen, 1.62 %; sulphur, 1.13 %; water, 1.70 %; ash, 6.65 %. Assume the factor for excess as 3.

**281.** If 1 volume of water at  $+20^{\circ}\text{C}$ . absorb 650 volumes of  $\text{NH}_3$ , what weight of ammonia will be taken up by 1 l. of water at the same temperature?

**282.** What weight of  $\text{NaOH}$  will neutralize 100 l. of  $\text{HCl}$ ?

**283.** At  $0^{\circ}\text{C}$ . 1 volume of water will absorb 500 times its own volume of  $\text{HCl}$ . How much will 500 g. of water at  $0^{\circ}$  increase in weight by absorbing all the  $\text{HCl}$  it can?

**284.** What weight of  $\text{HCl}$  can be obtained from 25 g. of salt? How much  $\text{Na}_2\text{SO}_4$  is formed?

**285.** A silver coin containing 8 % of copper weighs 2.43 g. If the coin is dissolved in  $\text{HNO}_3$ , how many g. of  $\text{NaCl}$  will be needed to precipitate all the silver as  $\text{AgCl}$ ?

In the above, what weight of iron will be required to reduce the  $\text{AgCl}$  to metallic silver and what will be the weight of the silver obtained?

**286.** How many tons of pure hematite would be needed for the production of 100 tons of iron in the blast furnace, assuming that 2.3 % of the iron in the ore passes into slag?

**287.** How much coke would be needed to reduce 50 tons of pure hematite?

**288.** An ore contains 36.4 % of "Ruby Copper" ( $\text{Cu}_2\text{O}$ ). With what weight of charcoal must 10 tons be heated to reduce all the  $\text{Cu}_2\text{O}$  to metallic copper?

( $\text{Cu}_2\text{O} + \text{C} = 2 \text{Cu} + \text{CO}$ .) Find weight of copper.

**289.** How much potassium hydroxide will react with 20 g. of chlorine, in the formation of potassium chlorate?

**290.** How much potassium hydroxide must be used to obtain 50 g. of potassium chlorate?

**291.** How much sodium hydroxide will neutralize 10 g. of nitric acid?

**292.** How much sulphuric acid will be neutralized by 20 g. of potassium hydroxide?

**293.** How much hydrochloric acid will neutralize 25 g. of sodium hydroxide?

**294.** If 40 cc. of a solution of potassium hydroxide are neutralized by 25 cc. of a solution of hydrochloric acid containing 0.001 g. of the acid per cc., what weight of the hydroxide is contained in 10 cc. of its solution?

**295.** If 50 cc. of a solution of nitric acid are neutralized by 70 cc. of a solution of sodium hydroxide containing 0.004 g. of the alkali per cc., what weight of the acid is contained in  $\frac{1}{2}$  l. of its solution?

**296.** If 25 cc. of a solution of potassium hydroxide are neutralized by 45 cc. of a solution of sulphuric acid containing 0.002 g. of the acid per cc., what weight of the hydroxide is contained in one l. of its solution?

**297.** How much ammonia gas can be obtained from 40 g. of ammonium chloride?

**298.** How much ammonia is necessary for the production of 20 g. of ammonium nitrate?

**299.** What weight of nitrogen will appear when 100 g. of chlorine are taken up in the decomposition of ammonia?

**300.** How much nitrous anhydride is obtainable from 60 g. of potassium nitrite?

**301.** Calculate the weight of a l. of nitric oxide under standard conditions.

**302.** What is the weight of a l. of hydrocyanide under standard conditions?

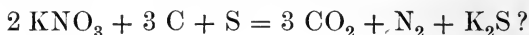
**303.** A l. of gas under 700 mm. pressure at  $+40^{\circ}$  C. weighs 1.307 g.; what is its molecular weight?

**304.** Five l. of a gas under 2 atmospheres pressure at  $+50^{\circ}$  C. weigh 10.6 g.; what is the molecular weight of the gas?

**305.** Seven l. of sulphur dioxide, at  $+90^{\circ}$  C., are produced by burning 12 g. of sulphur in oxygen; what is the pressure of the gas?

**306.** The oxygen obtained from 100 g. of potassium chlorate occupies 30 l. under the pressure of 70 cm. of mercury; what is the temperature of the gas?

**307.** What volume of carbon dioxide at  $+ 20^{\circ}\text{C}$ . and 740 mm. pressure would be produced by the explosion of 10 g. of gunpowder (supposing gunpowder to be  $2\text{KNO}_3 + 3\text{C} + \text{S}$ ) according to the equation



**308.** What volume of nitrous oxide, at  $+ 30^{\circ}\text{C}$ . and 800 mm. pressure, is obtainable from 100 g. of ammonium nitrate?

**309.** How many l. of hydrogen will result from the electrolysis of 50 g. of water, when the gas is collected over mercury, the level within the tube being 90 mm. above that without, and the temperature and barometric pressure being  $+ 23^{\circ}\text{C}$ . and 745 mm. respectively?

**310.** How many g. of water may be obtained by burning a quantity of hydrogen occupying 400 l. at  $+ 50^{\circ}\text{C}$ . and 600 mm. pressure?

**311.** Ten l. of a compound weigh 19.8 g. If  $\frac{8}{11}$  of it is oxygen and the remainder carbon, find its formula.

**312.** What will be the volume of a gas at 760 mm. pressure and  $+ 60^{\circ}\text{C}$ ., which is 2 l. at 380 mm. and  $+ 90^{\circ}\text{C}$ .?

**313.** If 70 cc. of nitrous oxide should break up, what would be the weight of each constituent?

**314.** A mixture of lead sulphate and barium sulphate weighed 4 g. and analysis of the mixture gave 1.62 g. of  $\text{SO}_4$ ; what are the weights of lead sulphate and barium sulphate present in the mixture?



**315.** A mixture of the acid sulphates of sodium and potassium weighs 0.5 g., and analysis of the mixture shows 0.395 g. of  $\text{SO}_4$ ; what weights of sodium and of potassium are contained in the mixture?

**316.** A mixture of acid and neutral potassium carbonates weighs 1 g., and contains 0.4 g. of carbon dioxide; what is the weight of each carbonate?

**317.** A sample of pure dolomite weighs 1 g. and yields 0.48 g. of carbon dioxide; what weights of calcium oxide and of magnesium oxide does it contain?

**318.** Which is the more economical oxidizing agent, potassium nitrate at 5 cts. a lb. or sodium nitrate at  $5\frac{1}{2}$  cts. a lb.?

**319.** Which is more economical for neutralizing an alkali, 60 % nitric acid at 6 cts. a lb. or 30 % HCl at 3 cts. a lb.?

**320.** Which is the most economical for making carbon dioxide, sodium dicarbonate at 3 cts. a lb., sodium carbonate crystallized at  $2\frac{1}{2}$  cts. a lb., or calcium carbonate (marble) at 1 ct. a lb.?

**321.** Which is the more economical for the preparation of anhydrous ammonia, ammonium sulphate at 8 cts. a lb. or ammonium chloride at 11 cts. a lb.?

**322.** Which is the more economical oxidizing agent, potassium chlorate at 8 cts. a lb. or sodium chlorate at 10 cts. a lb.?

**323.** Given two iron ores, one a lake ore containing 62 % of iron and the other an ore containing 45 % of iron, how much of each must be used to give 100 tons of mixture containing 53 % of iron?

**324.** Suppose we wish to form 100 tons of a mixture of ores containing 10 % of copper, and we have at our disposal lots containing 7 % and 18 % respectively; how many tons of each must be taken ?

**325.** Given two iron ores, one containing 0.52 % of phosphorus and the other 0.14 %, how much of each must be mixed to give 20 tons (2240 lb. to the ton) containing 0.22 % of phosphorus ?

**326.** Given lead ores containing 60 % and 25 % of lead respectively, how many lbs. of each must be mixed to give 5000 lb. containing 45 % of lead ?

**327.** Suppose we have 10 tons of coal containing 2.5 % of sulphur. We have also supplies of coal containing 0.80 % and 1.10 % of sulphur. How much of each shall we add to the 10 tons to make 20 tons containing 1.80 % of sulphur ?

**328.** Coal contains about 2 % of nitrogen. Assuming that 75 % of this amount escapes as ammonia on distillation, calculate the amount of coal required to furnish the sal-ammoniac needed to produce 10 Kg. of  $\text{NH}_4\text{OH}$ .

**329.** If 100 volumes of Manchester cannel gas contained 4.98 volumes of olefines which yielded on combustion 13.93 volumes of carbon dioxide, what were the volumes of  $\text{C}_2\text{H}_4$  and  $\text{C}_4\text{H}_8$  contained in the gas ?

**330.** One  $\text{ft.}^3$  of hydriodic acid is decomposed by an excess of bromine; how many  $\text{ft.}^3$  of hydrobromic acid are formed ?

**331.** If 5 l. of chlorine are mixed with 5 l. of carbon monoxide, what volume of phosgene gas is produced, and how much hydrochloric acid and carbon dioxide would be produced by the decomposition of this gas with water ?

**332.** How many g. of water at  $0^{\circ}\text{C}$ . would be frozen by the removal of the heat required to evaporate 50 g. of liquid ammonia?

**333.** Find the density of the gas the formula of which is  $\text{N}_2\text{O}_5$ . Find the weight of a l. of phosphine.

**334.** Calculate the volume of hydrochloric acid solution (density 1.10 and 20.9% pure acid) that is required to make 500 g. of barium chloride from the carbonate.

**335.** What volume of air containing 21% of oxygen by volume is required to burn 248 g. of phosphorus?

**336.** If 25.82 l. of nitric oxide diffuse through a certain apparatus in 50 minutes, what volume of hydrogen will diffuse under the same conditions?

**337.** How many g. of sodium chloride dissolved in a l. of water would be required to elevate the boiling point of the solution  $0.52^{\circ}\text{C}$ .?

**338.** How much white lead should be obtained theoretically from 65 Kg. of lead?

**339.** How much air would be necessary to change 6 l. of nitrogen dioxide into the trioxide? (Consider all measurements at  $0^{\circ}\text{C}$ . and 760 mm.)

**340.** Suppose we had a bar of aluminum weighing 1800 g., how many cc. of water would it displace?

**341.** How much sodium nitrate (98% pure) would have to be present in a fertilizer that contained 4% of nitrogen, assuming that all the nitrogen came from the nitrate?

**342.** How many g. of KI dissolved in a l. of water are necessary to lower the freezing point of the solution  $+1.86^{\circ}\text{C}$ .?

343. Find the density of the gas having the formula  $N_2$ .

344. Find the weight of a l. of hydrogen chloride.

345. One l. of gas weighs 0.09 g.; find its molecular weight. What is this gas?

346. How much sodium would be necessary, assuming exact proportions, to produce 3 Kg. of aluminum from 2  $AlCl_3$ , 2  $NaCl$ ?

347. How many cc. of a solution of potassium permanganate which contains 40 g. to the l. would be necessary to oxidize 0.5 g. of iron from the ferrous to the ferric condition?

348. How much aluminum should we theoretically obtain from an ore containing 90 % of bauxite?

349. If 500 g. of sulphur containing 17 % impurities are burned in air, what weight of oxygen is needed?

350. If 2 g. of gunpowder produce 600 cc. of gas at  $0^\circ C.$ , what is the volume at  $+2500^\circ C.$ ?

351. What weight of carbon is contained in (a) 1 l.  $CO$ ; (b) 1 l.  $CO_2$ ; (c) 1 l.  $C_2H_2$ ; (d) 1 l.  $CH_4$ ; (e) 1 l.  $C_2H_4$ ?

352. The velocity of diffusion of nitrogen is 1.0143; how many atoms of nitrogen are there in a molecule?

353. The velocity of diffusion of oxygen is 0.9487; how many atoms of oxygen are there in a molecule?

354. If 25 cc. of dilute  $H_2SO_4$  required 2.44 g.  $BaCl_2$ , 2  $H_2O$  for complete precipitation, what percentage of water was present in the dilute acid?

355. How much  $H_2SO_4$  is needed to decompose 27 g. of common salt?

**356.** What is the weight of 40 l. of  $\text{NH}_3$  at  $0^\circ \text{C}$ . and 760 mm.? If 40 l. of  $\text{HCl}$  are mixed with it, what is the weight of the residue?

**357.** If 20 g. oxalic acid are warmed with  $\text{H}_2\text{SO}_4$ , how much  $\text{CaCO}_3$  can be produced by passing the products through lime water and what volume of gas passes over?

**358.** If 130 g. of  $\text{NH}_3$  burn, what are the weights of the products of combustion?

**359.** Calculate the effect of adding 2 volumes of a saturated (3.90 molar) solution of potassium chloride to a saturated (0.52 molar) solution of potassium chlorate. Assume that 1.95 molar  $\text{KCl}$  is 0.71 ionized.

**360.** The sum of the readings of the same temperature on the F. and C. scale is 172; what is the reading on each?

**361.** A sample of carbon containing 85 % of carbon and 3 % of hydrogen is burned; what volume of air containing 21 % of oxygen is used?

**362.** What weight and volume of air contain 1 g. of nitrogen?

**363.** What volume of chlorine acting on  $\text{NH}_3$  will give 10 l. of nitrogen?

**364.** Give the sum and the difference in weight of 20 l. of nitrogen and 20 l. of air.

**365.** To give 6 l. of  $\text{PH}_3$ , how much zinc must be treated with sulphuric acid to give the required amount of hydrogen?

**366.** If 13 g.  $\text{As}_2\text{S}_3$  have been thrown down in a solution by the passage of  $\text{H}_2\text{S}$ , what volume of  $\text{H}_2\text{S}$  at  $+16^\circ \text{C}$ . and 761 mm. was used?

**367.** How much  $\text{As}_2\text{O}_3$  corresponds to 12 g. of  $\text{As}_2\text{S}_3$ ?

**368.** If 1.311 g. of  $\text{As}_2\text{S}_3$  were obtained as a result of the analysis of the stomach in a poison case, how much paris green was swallowed?

**369.** To produce 20 g.  $\text{P}_2\text{O}_5$ , how much (a) phosphorus and how much (b)  $\text{PH}_3$  must be burned?

**370.** One g. of hydrogen is passed over 100 g. of  $\text{CuO}$ ; find weight of  $\text{H}_2\text{O}$  and the loss of the  $\text{CuO}$ .

**371.** How many oz. of gold per ton are represented by 40 parts to the million? What would be the value of such ore, rating gold at \$20.00 per oz.?

**372.** From the following data calculate the weight in Kg. of each constituent of the air in a room  $12' 0'' \times 15' 0'' \times 9' 0''$ : — Composition of the air by volume: nitrogen, 77.35%; oxygen, 20.77%; argon, 0.94%; water vapor, 0.90%; carbon dioxide, 0.03%; a l. of air of above composition weighing 1.29 g.

**373.** From the following data calculate the weight in Kg. of each constituent of the air in a room  $12' \times 15' \times 9'$ : assume water vapor = 0.90% and carbon dioxide = 0.03%.

**374.** The sp. gr. of zinc is 7.2. A block of it 2 cm.  $\times$  3 cm.  $\times$  4 cm. is dissolved in  $\text{HCl}$ . How much hydrogen (a) by weight and (b) by volume is evolved?

**375.** A block of charcoal  $\frac{9}{10}$  pure is 5 cm.  $\times$  6 cm.  $\times$  7 cm., and has sp. gr. = 1.5; how much  $\text{CO}_2$  by volume ought to form in burning it?

**376.** If  $\text{PbCO}_3$  has a sp. gr. = 6.46, how much  $\text{CO}_2$  by volume could be obtained from a cubical mass of it, 7 cm. on a side?

377. At 60 cents per oz., what is the value of the silver in  $\frac{1}{4}$  lb. of silver nitrate?

378. If a skeleton weighs 21 lb. and is 56%  $\text{Ca}_3(\text{PO}_4)_2$ , how many matches can be tipped with the phosphorus it contains, if 1 lb. of phosphorus serves to tip a million matches?

379. How much iron is present in a solution which requires 47 cc. of a  $\frac{M}{4}$  solution of  $\text{KMnO}_4$  to produce a pink color?

380. If 5.24 g. coke on burning give 17.54 g. of  $\text{CO}_2$ , what is the percentage of carbon in the coke?

381. If 2 g. were lost by heating a piece of Iceland spar, what weight and volume of  $\text{CO}_2$  were produced at  $+13^\circ \text{C}$ . and 700 mm.?

382. How much  $\text{HF}$  by volume is needed to reduce the weight of a piece of glass 3 g.?

383. If 300 tons carbon (87% pure) are burned in air, how much oxygen is needed? What volume of gas is produced at  $-6^\circ \text{C}$ . and 721 mm.?

384. What volume of gas is given by 1 g. of "black lead" on complete combustion at standard conditions?

385. If 12.1764 l. of nitrogen diffuse through a porous plate in the time that it takes 9.7044 l. of  $\text{CO}_2$  to do so, what is the density of  $\text{CO}_2$  compared with air?

386. If 300 l. of nitrogen dioxide diffuse through a porous plate in 1 hour, what volume of silicon tetrafluoride will diffuse through in the same time?

387. The sp. gr. of bromine is 3.18; find the volume of vapor given off when measured at  $+90^\circ \text{C}$ .

**388.** How much  $\text{H}_2\text{SO}_4$  will 20 g. of  $\text{SO}_3$  dissolved in water yield?

**389.** If 60 l. of nitrogen tetroxide diffuse through a porous plate in 1 hour, what volume of chlorine tetroxide will diffuse through in the same time?

**390.** How many g. of  $\text{MnO}_2$  and how many cc. of a solution of  $\text{HCl}$  (containing 20 % of  $\text{HCl}$ ) are necessary to evolve 1.86 l. of chlorine at  $0^\circ \text{C}$ . and 760 mm.?

**391.** How much water will be formed by the action of (a) copper upon 98 g. of hot hydrogen sulphate; (b) hydrogen fluoride upon 60 g. of silicon dioxide?

**392.** If 120 cc. of a mixture of  $\text{CO}$  and hydrogen are exploded with oxygen, 40 cc. of gas remain, of which 30 cc. are absorbed by  $\text{KOH}$  solution; find the composition of the mixture.

**393.** If 20 l. of hydrogen diffuse through a porous plate in 10 minutes, determine the volume of nitrogen monoxide that will diffuse through in the same time.

**394.** If  $x$  cc. of a gas are measured at  $+15^\circ \text{C}$ . and 755 mm., the normal volume is 1000 cc.; find the numerical value of  $x$ .

**395.** The sp. gr. of ammonia gas under standard conditions is 0.591; what is its sp. gr. when the barometer stands at 750 mm.?

**396.** The sp. gr. of chlorine is 2.45 under standard conditions; what is the barometric height when the sp. gr. is 2.40?

**397.** One l. of hydrogen under standard conditions weighs 0.0896 g.; what is the weight of 1 l. when the barometer stands at 740 mm.?



398. One l. of air under standard conditions weighs 1.29 g.; what is the weight of 2.5 l. when the barometer stands at 755 mm.?

399. If 72 g. of an aqueous solution of  $\text{H}_2\text{O}_2$ , when decomposed, give 2.79 l. of oxygen at  $0^\circ \text{C}$ . and 760 mm., what is the percentage of  $\text{H}_2\text{O}_2$  in the solution?

400. Sea water contains 0.00475 g.  $\text{CaCO}_3$  per l.; what quantity of sea water would be needed to prepare 56 g. of lime?

401. If 21 g. of borax are heated to constant weight, what is the loss and what per cent. of the whole?

402. Silicon fluoride was passed into cold water and 27 g. of  $\text{SiO}_2$  were produced; how much of the gas was used?

403. A gas is composed of 92.3 % of C and 7.7 % H; how many atoms of hydrogen are united to 2 atoms of carbon?

404. If hydrogen sulphide is diluted with 10 times its volume of hydrogen, what volume of it, estimated as pure gas, will be dissolved by 20 volumes of alcohol at  $0^\circ \text{C}$ . and 760 mm.?

405. A Dumas bulb full of air weighs 13.3125 g. After being filled with the vapor of carbon tetrachloride at  $100^\circ \text{C}$ ., it weighs 13.7969 g. Filled with water, it weighs 141.3 g. The barometric reading is 755 mm. What is the vapor density referred to air at  $0^\circ \text{C}$ . and 760 mm.?

406. What volume of air is required to oxidize one formula-weight of zinc sulphide to  $\text{ZnO}$  and  $\text{SO}_2$ , and what volume of sulphur dioxide is produced? Is the

product more or less diluted with nitrogen than when pure sulphur is burned, and by how much?

**407.** How much chlorine is needed to displace bromine in a solution of NaBr containing 16 g.?

**408.** How many g. of sulphur in 3 l. of  $\text{SO}_2$ ; 6 g. of  $\text{SO}_3$ ; 10 l. of  $\text{H}_2\text{S}$ ; 16 g. of  $\text{K}_2\text{SO}_4$ ?

**409.** If 8.132 l. of CO diffuse through an opening in the time that it takes 10.7 l. of marsh gas to pass through, what is the density of marsh gas compared with that of air?

**410.** If 3.804 l. of oxygen diffuse through a certain opening in the time that it takes 4.066 l. of CO to pass through, what is the density of CO compared with that of air?

**411.** Determine the density of oxygen compared with air, given that 5.706 l. of oxygen diffuse through a hole in the time it takes 22.68 l. of hydrogen to pass through.

**412.** What volume of HI weighs the same as  $\frac{1}{2}$  l. of oxygen at  $0^\circ \text{C}$ . and 760 mm.?

**413.** A solution of common salt required 6 g. of  $\text{AgNO}_3$  to precipitate it completely as  $\text{AgCl}$ ; how much sodium was present?

**414.** If 150 tons of  $\text{H}_2\text{SO}_4$  are made from 110 tons of a crude native sulphur, find the percentage of sulphur in the native product.

**415.** One ton of iron pyrites containing 50 % sulphur will make how much  $\text{H}_2\text{SO}_4$ ?

**416.** A fire extinguisher contains 2 lb. of  $\text{NaHCO}_3$ ; how much  $\text{H}_2\text{SO}_4$  is needed to neutralize it?

**417.** One g. of coal gave 0.2000 g. of barium sulphate; 1 g. of magnesium oxide and 0.50 g. of sodium carbonate were used in the analysis. It was found upon a blank analysis of the reagents that 10 g. of the magnesia and 5 g. of sodium carbonate together gave 0.1500 g. of  $\text{BaSO}_4$ . What is the percentage of sulphur in the coal?

**418.** In the analysis of a limestone, 1 g. was taken for analysis, and a precipitate of  $\text{CaSO}_4$  weighing 0.812 g. was obtained. A precipitate of magnesium pyrophosphate weighing 0.385 g. was also obtained. What is the percentage composition of the limestone in  $\text{CaO}$  and  $\text{MgO}$ ?

**419.** Find the weight and volume of oxygen needed for the complete combustion of 10 g. of  $\text{C}_2\text{H}_4$ .

**420.** How much  $\text{CO}_2$  in a room 10 m.  $\times$  6 m.  $\times$  4 m., if there is 1 volume  $\text{CO}_2$  in 10,000 volumes of air?

**421.** How many l. of  $\text{CO}_2$  must be passed over hot charcoal to give 100 g. of  $\text{CO}$ ?

**422.** Sixty l. of steam require what volume of the component gases?

**423.** What volume of chlorine would be equal to 24 l. of methane at  $0^\circ \text{C}$ . and 760 mm.?

**424.** If 200 cc. of oxygen are exploded with 40 cc. of marsh gas, what are the volumes and percentage compositions of the residual gases?

**425.** If 3.36 g. of three different metals liberate respectively 1344 cc., 3136 cc., and 1636 cc. of hydrogen, what metal was dissolved in each case?

**426.** What weight of alcohol and what volume of  $\text{CO}_2$  on fermentation are produced by 21 g. of grape sugar?

**427.** Gunpowder is composed of 75 parts niter, 15 parts charcoal and 10 parts sulphur. If all the carbon forms  $\text{CO}_2$  and the nitrogen is liberated, find the volume of these gases evolved on the explosion of 1 g. of gunpowder at standard conditions.

**428.** At the ordinary temperature and pressure, water absorbs 50 % of its weight of ammonia. Calculate the amount of sal-ammoniac and quicklime needed to produce 10 Kg. of hartshorn.

**429.** According to Boussingault, a  $\text{m}^2$  of leaf will decompose in sunlight 1.108 l. of carbon dioxide in an hour. Calculate in tons the amount of carbon assimilated in an hour by 1,000,000 trees, each possessing 100,000 leaves and each leaf containing  $25 \text{ cm}^2$ . Calculate the volume of the carbon so assimilated, on the assumption that it possesses a sp. gr. of 2.6.

**430.** If sea water contains 0.36 parts  $\text{MgBr}_2$  in 1000, how much of it would be needed to give 1 l. of bromine (sp. gr. = 3.18)?

**431.** Iodic acid may be obtained by passing a stream of chlorine through water containing iodine in suspension; how much iodine and chlorine will be needed to prepare 100 g. of iodic acid?

**432.** What weight of iron sulphide will be needed to yield a l. of hydrogen sulphide at  $0^\circ \text{C}$ . and 760 mm., and how much air will be required to burn this gas completely to water and sulphur dioxide?

**433.** Manchester coal gas contains 35 % by volume of marsh gas; calculate the weight of this gas in a gasometer holding 100,000  $\text{ft}^3$  of coal gas.

**434.** If 100 g. of pure silver cyanide are shaken up with 120 g. of hydrochloric acid containing 26.1 % of HCl, how much silver chloride is produced and what is the percentage amount of hydrocyanic acid in solution?

**435.** A water solution of potassium iodide having 20 g. in it is treated with chlorine; what volume of chlorine will be needed to replace all the iodine?

**436.** Sulphuric ether vapor is exploded with 60 times its volume of air; find volumes of residual gases.

**437.** If 300 cc. of oxygen were added to 200 cc. of a mixture of H, CO and  $\text{CH}_4$ , and if, after exploding, the volume was 220 cc., and after washing with KOH solution 80 cc., what was the composition of the mixture?

**438.** Five volumes of a hydrocarbon,  $\text{C}_n\text{H}_{2n}$ , are submitted to combustion; how many volumes of oxygen are required for its complete combustion and how many volumes of  $\text{CO}_2$  are generated?

**439.** Find weight of hydrogen necessary to unite with oxygen in 200 g. of air to form water.

**440.** Find volume of oxygen needed to unite with 2 l. of hydrogen to form water. What volume with (a) 60 cc.; (b) 60 dm.<sup>3</sup>; (c) 60 l.; (d) 60 qt.; (e) 60 M.<sup>3</sup>; (f) 700 volumes?

**441.** Find the weight of (a) 700 cc. of dry hydrogen at 0° C. and 760 mm.; (b) of 2000 cc.; (c) of 13 l.; (d)  $16\frac{1}{2}$  dm.<sup>3</sup>; (e) 3 m.<sup>3</sup>

**442.** One Kg. of water contains hydrogen and oxygen in what proportion by weight and by volume?

**443.** Find the weight of 1200 l. of phosphorus vapor.

**444.** Arsenic is burned in oxygen and 103 g. of the oxide are produced; how much arsenic was used?

445. A tank holds 20 g. of oxygen ; what weight (a) of  $N_2O$  and of (b) NO will it hold ?

446. If potassium is heated in contact with 10 g. of  $N_2O$  and NO separately, what volume of nitrogen will be left in each case?

447. How much pure  $HNO_3$  in 200 tons of  $HNO_3$ , 200 g. of which will neutralize 88.6 g. of pure NaOH?

448. What loss in weight should 100 lb. of gypsum undergo when heated to  $+250^\circ C.$ ?

449. If 0.4 g. of iron dissolved in acid gave 167.4 cc. of hydrogen at  $+12^\circ C.$  and 750 mm., what is the purity of the iron?

450. How much coke (90 % pure carbon) would be needed to make 100 m.<sup>3</sup> of CO, measured at  $+30^\circ C.$  and 850 mm.?

451. If 0.2 g. of a metal yield 77.39 cc. of hydrogen, how much will yield 309 cc.?

452. If 600 cc. oxygen at  $+12^\circ C.$  and 720 mm. are required, and the materials on hand are bleaching powder, cobalt oxide and water, how much bleaching powder will be used?

453. What volume of HI contains 2 g. of iodine at standard conditions?

454. If 1 cc. HCl neutralizes 0.0106 g.  $Na_2CO_3$ , what weight of AgCl will be thrown down when 1 cc. is added to excess of  $AgNO_3$  solution?

455. A mixed gas consists of hydrogen 46 %,  $CH_4$  40 %, and olefiant gas 14 % by volume ; how much air would be needed to burn 100 l. of this gas?

456. Find the weight of 20 l. of air containing 21 % of oxygen and 79 % of nitrogen at  $0^\circ C.$  and 760 mm.

457. In 300 g. of common alum, find how much aluminum is present.

458. A slab of marble weighs 200 Kg. (a) How much lime will it make? (b) What volume of water will just slake this lime? (c) How many l. of air will transform it into the carbonate? (1 volume of  $\text{CO}_2$  in 10,000 volumes of air.)

459. When 50 g. of  $\text{ZnO}$  were made, how much zinc was needed and what volume of oxygen was used?

460. What weight of  $\text{HCl}$  would be needed to dissolve 200 g. of  $\text{ZnO}$ ?

461. If 20 cc. of  $\text{H}_2\text{SO}_4$  solution yield 2.468 g. of  $\text{BaSO}_4$  when precipitated with  $\text{BaCl}_2$ , what weight of this acid will be required to neutralize 10 g. of  $\text{Na}_2\text{CO}_3$ ?

462. What volume of sulphuric ether vapor corresponds in weight to (a) 1 l. of nitrogen; (b) 1 l. of air; (c) 1 l.  $\text{CO}_2$ ; (d) 1 l. of chlorine?

463. What weight of phosphoric acid could be made from 10 lb. of phosphorus?

464. On heating sodium phosphate till there is no longer a loss in weight, one gets 100 g. of residue; what was the original weight?

465. An unknown volume of hydrogen sulphide required 110.34 cc. of chlorine for complete decomposition; what was the volume of the hydrogen sulphide?

466. One g. of  $\text{NaCl}$  in solution was mixed with another solution containing 2 g. of  $\text{AgNO}_3$ . Find weight of residue. Which one was in excess and how much?

467. How much  $\text{CaC}_2$  will produce enough gas from water to yield on combustion 20 l. of  $\text{CO}_2$ , measured at  $+10^\circ \text{C}$ . and 730 mm.?

**468.** If 25 g. of sodium acetate yield a certain weight of  $\text{CH}_4$ , what volume of air (21 % oxygen) is needed to burn this gas?

**469.** If 24 g. of magnesium are heated in a current of nitrogen, what is the weight of the product?

**470.** I need 2 l. of  $\text{CO}_2$ . What weights of (a)  $\text{Na}_2\text{CO}_3$  and (b)  $\text{NaHCO}_3$  would have to be treated with acid to give this volume?

**471.** What is the weight of 100 l. of  $\text{SO}_2$ , measured at  $+31^\circ \text{C}$ . and 721 mm.?

**472.** What volume of  $\text{CO}$ , at  $+800^\circ \text{C}$ . and 700 mm., would be required to reduce 1 Kg. of ferrous oxide to metallic iron?

**473.** A l. of mineral water yielded 0.0134 g. of  $\text{AgI}$ ; how much iodine is contained in 1,000,000 cc. of the water?

**474.** From the vapor densities of these gases compute their molecular weights: (a) oxygen, 16; (b) carbon dioxide, 22; (c) nitrogen, 14; (d) nitric oxide, 15; (e) carbon monoxide, 14; (f) marsh gas, 8.

**475.** Find the vapor densities of these molecules, computing the molecular weights by affixing the atomic weights: (a)  $\text{HCl}$ ; (b)  $\text{C}_2\text{H}_2$ ; (c)  $\text{NH}_3$ ; (d)  $\text{PH}_3$ ; (e)  $\text{O}_2$ ; (f)  $\text{P}_4$ ; (g)  $\text{Hg}$ ; (h)  $\text{CO}$ ; (i)  $\text{CH}_4$ .

**476.** (a) The vapor density of alcohol is 23. Ascertain which of the following is the proper formula for alcohol: (1)  $\text{C}_4\text{H}_{12}\text{O}_2$ ; (2)  $\text{C}_2\text{H}_6\text{O}$ ; (3)  $\text{C}_8\text{H}_{24}\text{O}_4$ . (b) The vapor density of acetic acid is 29.7, and the percentage composition indicates one of these symbols. Which is correct: (1)  $\text{H}_2\text{CO}$ ; (2)  $\text{H}_6\text{C}_3\text{O}_8$ ; (3)  $\text{H}_4\text{C}_2\text{O}_2$ ? (c) To which of these formulas does the density 33.5 apply: (1)  $\text{ClO}_2$ ; (2)  $\text{Cl}_2\text{O}_4$ ?



**477.** What weight of calcium carbonate is required to neutralize 400 cc. of hydrochloric acid solution which contains 100 g. of the pure substance?

**478.** The specific heat of phosphorus is 0.189. The vapor density of phosphorus is 62. How many atoms are there in the molecule of phosphorus gas?

**479.** How much nitrogen may be obtained from 22 g. of ammonium nitrite? What volume would it occupy at  $+20^{\circ}\text{C}$ . and 756 mm. pressure?

**480.** In every 100 parts of nitric acid there are 1.58 parts of H, 76.19 parts of O, and 22.23 parts of N. Does this fix the formula of the acid? Why do we accept the formula  $\text{HNO}_3$ ?

**481.** If 100 g. of gypsum are heated, what volume of steam at  $+300^{\circ}\text{C}$ . is given off?

**482.** How much carbon dioxide by weight and by volume can be obtained from 53 g. of sodium carbonate? What volume would the gas occupy at  $+20^{\circ}\text{C}$ . and under a pressure of 75 mm.?

**483.** A l. of a certain gas weighs 7.50 g., while a l. of hydrogen under the same conditions weighs 0.050 g. The atomic weight of the element composing the gas is 75. How many atoms are there in one molecule of the gas?

**484.** What volume of oxygen under standard conditions can be obtained from 5 g. of potassium chlorate?

**485.** What is the atomic weight of silver, if the specific heat is 0.056 and the atomic heat is 5.99?

**486.** Find the specific heat of silver, if the atomic weight is 107 and the atomic heat is 5.99.

**487.** Compute atomic heats from the data that follow: (a) Hg, at. wt. 199, sp. ht. 0.033; (b) iodine, at. wt. 126, sp. ht. 0.054; (c) U, at. wt. 238, sp. ht. 0.028; (d) Br, at. wt. 80, sp. ht. 0.1071.

**488.** Take 6.4 as the atomic heat of the following and the specific heats as given, and find the approximate atomic weights: (a) Al, 0.22; (b) Fe, 0.11; (c) Zn, 0.094; (d) K, 0.17; (e) Pb, 0.031.

**489.** Hydrogen is passed over hot copper oxide, and the water that is formed is absorbed by calcium chloride and its weight ascertained to be 3 g.; what has been the loss of weight of the tube containing the copper oxide?

**490.** Two l. of a gas which is half oxygen and half sulphur weigh 5.76 g.; what is its formula?

**491.** A compound of nitrogen and hydrogen, of which the nitrogen is  $\frac{14}{17}$ , weighs 0.765 g. to the l.; what gas is it?

**492.** Two l. of a compound of oxygen and nitrogen weigh 3.96 g. The nitrogen is  $\frac{7}{11}$  of the whole. What is the compound?

**493.** Find the specific heat of each of the following elements from the constant atomic heat 6.4: (a) Mg, at. wt. 24; (b) Ni, at. wt. 58; (c) Pt, at. wt. 193; (d) Na, at. wt. 23.

**494.** The atomic weight of copper is either 31.5 or 63; find which is correct if the specific heat is 0.094.

**495.** If zinc has an atomic weight of either 32.5 or 65 or 130, find which is correct if the specific heat of Zn is 0.094.

**496.** If 1 l. of acetylene is burned, what volume of oxygen is necessary for the combustion and what volume of carbon dioxide will be formed?

**497.** What weight of carbon dioxide would be obtained by burning 17 g. of carbon?

**498.** What volume of oxygen will unite with 730 cc. of carbon monoxide to form carbon dioxide and what will be the volume of the carbon dioxide produced?

**499.** Supposing standard conditions in each case, find the weight of a l. of ammonia,  $\text{NH}_3$ ;  $\text{CO}_2$ ;  $\text{CO}$ ;  $\text{N}_2$ ;  $\text{H}_2\text{S}$ ;  $\text{N}_2\text{O}_3$ ;  $\text{Cl}_2$ .

**500.** By analysis we find aluminum-methyl to contain 37.5 % of Al, 50 % of C, and 12.48 % of H. The vapor density is very nearly 72 at  $+160^\circ \text{C}$ ., but at  $+220^\circ \text{C}$ . it is found to be nearly 36. Can you account for the vapor density varying at the two temperatures? What is the formula of the compound?

**501.** Carbon and oxygen form what compounds? If 1 l. of oxygen combines with carbon to form each of these compounds, what will be its volume in each case, at the standard temperature and pressure?

**502.** What is the sp. gr. referred to air and to hydrogen of a gas that requires 12 minutes to escape through an opening, while the same volume of air under same conditions of temperature and pressure requires 20 minutes?

**503.** If an ore contains 10 % of moisture and 12 % of copper, what will be the percentage of copper in the ore dried at  $+105^\circ \text{C}$ ?

**504.** If an ore contains 15 % of moisture and 50 % of manganese, what will be the percentage of manganese in the dry ore?

**505.** What is the sp. gr. referred to air of a gas that escapes in 14.5 minutes through an opening, through which, at the same temperature and pressure, the same volume of air requires 19.5 minutes?

**506.** What is the vapor density of a gas that escapes in 7 minutes and 30 seconds from an opening, while the same volume of air under the same conditions requires 5 minutes and 10 seconds?

**507.** If a sample of coal contains 10% of ash on the dry basis, what is the percentage of ash in the natural coal containing 5% of moisture?

**508.** A sample of ore contained 20% of lead, 14% of zinc and 14% of water; what are the percentages of lead and zinc on the dry basis?

**509.** A clay was partially dried and then contained  $\text{SiO}_2$ , 50%, and water 7%; the original clay contained 12% of water; what is the percentage of the silica in the original sample?

**510.** Find the proportion by weight and by volume in which ethane gas will combine with oxygen.

**511.** A quantity of hydrogen measures 76 l. at  $+100^\circ \text{C}$ . and 746 mm. pressure; calculate its weight.

**512.** The equivalent of mercury is 100, and the formula of mercuric chloride is  $\text{HgCl}_2$ ; find its specific heat.

**513.** The formula of ethane is  $\text{C}_2\text{H}_6$ . Calculate the density of its vapor (*a*) compared with hydrogen; (*b*) compared with air.

**514.** If an ore contains 60% of iron in the dry sample, what is the percentage of iron in the natural ore which contains 10% of water?

**515.** What is the amount of "available oxygen" in a cc. of a solution of potassium permanganate containing 50 g. per l.?

**516.** Find the weight of 10 cc. of iron when sp. gr. is 7.85.

**517.** If 100 g. of a solution of hydrogen dioxide in water gave off, when heated, 5 l. of oxygen, what is the percentage of  $\text{H}_2\text{O}_2$  in the solution?

**518.** What weight of potassium permanganate, in acid solution, will be reduced by 5000 cc. of hydrogen sulphide at standard conditions?

**519.** Calculate the density (referred to air) of  $\text{C}_2\text{H}_4$ .

**520.** (a) The vapor density of chlorine is 35, the atomic weight is 35; find the number of atoms per molecule. (b) The vapor density of Zn is 32.5, its atomic weight is 65; how many atoms in its molecule? (c) Phosphorus has atomic weight 31, vapor density 62. compute as before. (d) The atomic weight of ozone is 16, its vapor density is 24; compute.

**521.** The atomic weight of copper is 63.3 and the formula of copper chloride is  $\text{CuCl}_2$ . The atomic weight of silver is 108. Determine the specific heat of silver and copper respectively.

**522.** What weight of ammonium chloride would be required in order to prepare 5 Kl. of ammonia?

**523.** How many cc. of nitrogen and of hydrogen would be produced by decomposing 20 cc. of ammonia by means of electric sparks?

**524.** What volume and weight of air would contain enough oxygen to burn exactly 25 l. of hydrogen?

**525.** What volume of chlorine would be required to convert 20 l. of sulphur dioxide dissolved in water into sulphuric acid, and what weight of sulphuric acid would be produced?

**526.** An iron rod 250 cm. long at  $+10^{\circ}$  C. is 0.09 cm. longer at  $+40^{\circ}$  C.; what will its length be at  $+60^{\circ}$  C.?

**527.** What volume of chlorine at N.T.P. would be required to convert an acidified solution of 5 g. of crystallized ferrous sulphate into a ferric salt?

**528.** How many cc. of a solution of potassium dichromate, containing 50 g. of the salt per l., would be required to oxidize 5 g. of ferrous chloride to a ferric salt?

**529.** What are the laws of diffusion of gases? If 20 volumes of hydrogen take 10 minutes to diffuse out of a vessel, how long will 50 volumes of oxygen take to diffuse out under like conditions?

**530.** If 0.428 g. of one of the oxides of manganese, when heated with hydrochloric acid, gave 42 cc. of chlorine, at N.T.P., which oxide of manganese was used?

**531.** Ferric oxide contains 30% of oxygen and its molecule 3 atoms of oxygen; what is its molecular weight?

**532.** If 1337 g. of copper sulphate yield 317 g. of copper and its molecular weight is 267.4, how many atoms of copper are there in a molecule of the sulphate?

**533.** A sample of silver nitrate weighing 2.40 g. was brought into solution and treated with a soluble chloride (excess). The weight of silver chloride precipitated was 2.01 g. What was the purity of the sample?

**534.** What weight of zinc (98 %) will be required for the liberation of the hydrogen from 10 g. of hydrochloric acid containing 39.1 % of HCl?

**535.** What weight of sulphuric acid containing 27.32 %  $\text{H}_2\text{SO}_4$  will be required for interaction with 2.17 g. of iron wire (99 % pure)?

**536.** On the top of a mountain the barometer stands at 70 cm. and the temperature is  $+10^\circ \text{C.}$ , while in the valley the barometer stands at 758 mm. and the thermometer at  $+20^\circ \text{C.}$ ; what are the relative densities of the air in the two places?

**537.** If 0.2815 g. of calcite was dissolved in 30 cc. of normal  $\text{HNO}_3$ , and the excess of acid determined by normal  $\text{NaOH}$ , of which 24.43 cc. were required, what percentage of  $\text{CO}_2$  did the sample contain?

**538.** If 2.0876 g. of hydrogen, when passed over heated oxide of copper, yielded 18.7406 g. of water, what is the equivalent of oxygen?

**539.** What is the absolute density of hydrogen at  $+20^\circ \text{C.}$  and 740 mm. pressure?

**540.** What is the absolute density of air at  $+10^\circ \text{C.}$  and 750 mm. pressure? The absolute density at the standard conditions is 1.293.

**541.** If 400 cc. of gas, with the density 16, and measured at  $+25^\circ \text{C.}$  and 750 mm. pressure, are to be brought to a temperature of  $+10^\circ \text{C.}$  and a pressure of 760 mm., what weight of this final gas can be contained in a vessel of 100 cc. capacity?

**542.** If 10 g. of a gas, measured at  $-48^\circ \text{C.}$  and 600 mm. pressure, were expanded by heating to  $+177^\circ \text{C.}$  and reducing the pressure to 480 mm., and the rarefied

gas, 250 cc., weighed 0.5 g., what was the original volume of gas and what was the density of the gas at its original and final volume?

**543.** If 10 l. of a gas, measured at  $+20^{\circ}\text{C}$ . and 750 mm. pressure, weighed 14 g., what weight of this gas could be contained in a smaller vessel holding 4 l. at  $+10^{\circ}\text{C}$ . and 760 mm. pressure?

**544.** What volume will 1000 cc. of a gas at  $+300^{\circ}\text{C}$ . and 740 mm. pressure occupy when reduced to standard conditions?

**545.** A piece of metal weighing 30 g. displaced 20 cc. of water; what is the relative density of this metal referred to water?

**546.** A vessel weighing 6.448 g. weighed 7.963 g. when filled with water and 8.266 g. when filled with a salt solution; what is the relative density of this solution referred to water?

**547.** What is the relative density of hydrogen sulphide referred to air and also to oxygen?

**548.** What is the relative density of hydrogen chloride referred to hydrogen, air, oxygen and chlorine?

**549.** If 8 g. of oxygen were mixed with 10.08 g. of hydrogen, and both gases were measured at the standard conditions, what was the relative density of this mixture?

**550.** A volume of gas, with the relative density 0.8757, was found to measure 1560 cc. when transferred to a vessel over water at  $+18^{\circ}\text{C}$ . and 742.4 mm.; what is the weight of the dry gas here concerned?

**551.** What volume of chlorine, measured at  $+10^{\circ}\text{C}$ . and 770 mm. pressure, would be required to convert 5 g. of phosphorus trichloride into the pentachloride?



552. What weight of pure sulphuric acid should be obtained from 100 tons of "pyrites" containing 35 % of sulphur?

553. The coefficient of linear expansion of iron is 0.000011; how much must an iron rod 40 ft. long be heated to expand 1 in.?

554. If 240 cc. of gas at a pressure of 740 mm. were admitted into an empty vessel of 800 cc. capacity, what was the pressure of the gas at this new volume?

555. If 500 cc. of oxygen, absolute density 1.429, were compressed to a volume of 125 cc. at constant temperature, what was the density of the gas at this final volume? What would be the weight of 50 cc. of the compressed gas?

556. A volume of gas measured 1 ft.<sup>3</sup> at  $-4^{\circ}$  F. and 30 in. pressure; what will be its volume at  $+68^{\circ}$  F. and 39.4 in. pressure?

557. What volume of liquid carbon dioxide, measured at  $0^{\circ}$  C., will be required to give 75 l. of the gas at  $0^{\circ}$  C. and 760 mm. pressure?

558. If 0.352 g. of a sample of pyrolusite was heated with hydrochloric acid, and the chlorine which was evolved was passed into a solution of potassium iodide, where it liberated 0.864 g. of iodine, what was the percentage of pure  $\text{MnO}_2$  in the sample?

559. If 0.5 g. of pyrolusite containing 92 % of pure  $\text{MnO}_2$  was heated with strong hydrochloric acid, and the resulting chlorine led into a solution of potassium iodide, what amount of iodine would be liberated?

560. If 35 cc. of a solution of potassium permanganate containing 15 g. per l. were required to oxidize

50 cc. of acidified solution of ferrous sulphate to ferric sulphate, what was the amount of metallic iron in a l. of the ferrous sulphate solution?

**561.** What volume of chlorine, at  $+17^{\circ}\text{C}$ . and 750 mm. pressure, would be required to convert 6 g. of tin into stannic chloride?

**562.** A volume of gas weighing 5 g. was expanded at a constant temperature till the pressure was reduced to  $\frac{1}{2}$  of its former value, and 500 cc. of the rarefied gas weighed 1.25 g. What was the original volume of the gas? Calculate also the original density, assuming the original observations made at standard conditions.

**563.** A volume of gas measuring 600 cc. at 760 mm. pressure was expanded to a volume of 1000 cc. at constant temperature; what was the final pressure of the gas?

**564.** A solution contains 48 g. of  $\text{Pb}(\text{NO}_3)_2$  per l.; how much  $\text{H}_2\text{SO}_4$  will 10 cc. of this solution precipitate?

**565.** Calculate the volume of chlorine liberated in the action of 40 g. of potassium dichromate upon a hydrochloric acid solution.

**566.** If 0.535 g. of a sample of pyrolusite, when acted on with a mixture of sulphuric acid and oxalic acid, produce 0.48 g. of carbon dioxide, what was the percentage of pure  $\text{MnO}_2$  in the sample?

**567.** The absolute density of oxygen is 1.429. When a given volume of this gas is warmed from  $0^{\circ}\text{C}$ . to  $+40^{\circ}\text{C}$ . under a constant pressure, what will the absolute density of the gas become?

**568.** A volume of gas with the absolute density 4 and measuring 250 cc. at  $0^{\circ}$  C. was expanded by warming, under constant pressure, to a volume of 600 cc. What increase in temperature was required, and what would be the weight of 300 cc. of the rarefied gas?

**569.** If 500 cc. of a gas, the absolute density of which is 6, must be reduced to a density of 0.75 at constant temperature, what will be the volume of this rarefied gas? Calculate also the weight of 400 cc. of the rarefied gas.

**570.** Calculate the relative density of hydrogen chloride, 5 l. of which under standard conditions weigh 8.205 g.

**571.** Calculate the relative density of chlorine, 100 cc. of which at standard conditions weigh 0.322 g.

**572.** The sp. gr. of chlorine is 2.449; what is its relative density upon the oxygen standard?

**573.** What is the weight of BaO in 1.9327 g. of  $\text{BaCrO}_4$ ?

**574.** What is the weight of CaO in 2.9478 g. of  $\text{CaSO}_4$ ?

**575.** What weight of  $\text{MnCO}_3$  yields on ignition 1.450 g. of  $\text{Mn}_3\text{O}_4$ ?

**576.** How much arsenic is there in 5 g. of  $\text{As}_2\text{S}_3$ ; of  $\text{As}_2\text{S}_5$ ; of  $\text{Mg}_2\text{As}_2\text{O}_7$ ?

**577.** How much AgI can be made from a lb. of pure silver; how much AgBr; how much AgCl?

**578.** If 1.10 g. of stibnite gave on analysis 0.5987 g. of  $\text{Sb}_2\text{O}_4$ , what was the percentage of antimony?

**579.** Air liquefies at  $-182^{\circ}$  C. Express this temperature on the Fahrenheit scale.

**580.** When water in an open dish boils at  $+209^{\circ}\text{F.}$ , what would be the reading of an accurate barometer placed near by?

**581.** Reduce 12 l. of oxygen, measured at  $+47^{\circ}\text{C.}$  and under a pressure of 782 mm. of mercury, to the standard conditions.

**582.** What will be the volume of 9 l. of hydrogen when heated to  $+120^{\circ}\text{C.}$  and under a pressure of 423 mm.?

**583.** Given 27 cc. of nitrogen at  $+14^{\circ}\text{C.}$  and 752.1 mm., what will be its volume at  $+20^{\circ}\text{C.}$  and 767.8 mm.?

**584.** What is the weight of 77.2 cc. of air, measured over water at  $+27^{\circ}\text{C.}$  and 758 mm. pressure?

**585.** What is the weight of 17 l. of hydrogen, measured at  $+12^{\circ}\text{C.}$  and 3 atmospheres pressure?

**586.** What is the weight of 85 cc. of  $\text{NH}_3$ , measured over mercury at  $+140^{\circ}\text{C.}$  and under a pressure of 770 mm.? Given the tension of mercury vapor at  $+140^{\circ}\text{C.}$  = 1.76 mm.

**587.** Find the density referred to air of chloroform vapor, given the following data for Dumas' method: weight of bulb and air at  $+20.5^{\circ}\text{C.}$  and 763.9 mm. = 34.8451 g.; weight of bulb and vapor at  $+116.5^{\circ}\text{C.}$  and 763.9 mm. = 35.8430 g.; volume of air in bulb at  $+20.5^{\circ}\text{C.}$  = 394.93 cc.

**588.** An object, the sp. gr. of which is 3.38, weighed 39.7250 g. in air when weighed with brass weights; what is its true weight?

**589.** An object, the sp. gr. of which is 0.95, weighed 17.8540 g. in air when weighed with brass weights; what is its true weight?

**590.** A bar of gold, sp. gr. = 19.3, weighed 10.73685 Kg. when weighed in air with brass weights; what is the true weight?

**591.** A piece of pyrrhotite, sp. gr. = 4.58, weighed in air 47.3854 g. when weighed with platinum weights; what is its true weight?

**592.** A piece of antimony, sp. gr. = 6.71, weighed 75 g. in air, the weights used being 50 g. brass, 20 g. and 5 g. platinum; what is the true weight?

**593.** If 50 cc. of  $\text{CH}_4$ , 50 cc. of  $\text{H}_2$ , and 50 cc. of  $\text{C}_2\text{H}_2$  were mixed with 450 cc. of oxygen and exploded, what would be the resulting volume at the same temperature and pressure? (Assume that the temperature is below  $+100^\circ \text{C.}$ )

**594.** How many amperes are flowing in a circuit which, in the course of 1 hr. and 15 min., has deposited 30.186 g. of silver?

**595.** How many g. of lead shot at  $+200^\circ \text{F.}$  must be used to raise the temperature of 400 g. of water from  $+40^\circ \text{F.}$  to  $+90^\circ \text{F.}$ ?

**596.** How much alcohol at  $-10^\circ \text{C.}$  must be mixed with 200 g. of chloroform at  $+30^\circ \text{C.}$ , that the final temperature may be  $+10^\circ \text{C.}$ ?

**597.** If a 50 g. lump of silver, left in ice water until it is cooled to  $0^\circ \text{C.}$ , is dropped into 100 g. of ether at  $+30^\circ \text{C.}$ , what will be the temperature of the mixture?

**598.** We have at our command a waste acid from the nitrating of glycerine, the composition of which is: sulphuric acid, 62.18%; nitric acid, 19.07%; and water, 18.75%. We also have an oil of vitriol containing 97% by weight of  $\text{H}_2\text{SO}_4$ , and a commercial nitric

acid containing 87 % by weight of  $\text{HNO}_3$ . What weights of each must be taken to give 1000 lb. of a mixture containing 60 % of  $\text{H}_2\text{SO}_4$ , 23 % of  $\text{HNO}_3$ , and 17 % of water, without adding water?

599. Bearing in mind that the molecule of mercury vapor is monatomic, calculate the weight of 500 cc. of that gas.

600. If we have two alloys, viz., a brass containing 65 % of copper and 35 % of zinc, and a German silver containing 56 % of copper, 24 % of zinc, and 20 % of nickel, supposing that there is no loss by oxidation or volatilization during the fusion, what will be the composition of the alloy formed by melting these two alloys together in such proportion that it contains 30 % of zinc?

601. Suppose that we desire to prepare 100 lb. of an alloy containing 70 % of copper, 20 % of zinc, and 10 % of tin; we have at our command, pure copper, a brass containing  $\frac{2}{3}$  copper and  $\frac{1}{3}$  zinc, and a solder containing  $\frac{1}{2}$  zinc and  $\frac{1}{2}$  tin: how much of each must be taken?

602. Given pure silver and an alloy containing 890 parts of silver and 110 parts of copper, how many oz. of each must be taken to form 1000 oz. of an alloy containing 925 parts of silver and 75 parts of copper?

603. Given a mixture of silver chloride and silver bromide, the weight of which is 1.5 g., analysis showing the mixture to contain 1 g. of metallic silver, what are the weights of the chlorine and of the bromine in the mixture?

604. The analysis of a dolomite gave 2 % of silica, and the remainder was calcium and magnesium carbonates. The determination of magnesia gave 10 % of  $\text{MgO}$ . What was the percentage of carbon dioxide?

**605.** How many ft.<sup>3</sup> of air at + 70° C. are needed for the combustion of 1 lb. of a coal having the analysis: carbon, 90 %; hydrogen, 5 %; oxygen, 3.5 %; nitrogen, 0.1 %; sulphur, 0.5 %. Assume the factor for excess as 2.

**606.** Calculate the number of ft.<sup>3</sup> of air at + 60° F. needed for the combustion of 1 ton of a coal having the composition: carbon, 74.60 %; hydrogen, 4.89 %; oxygen, 6.90 %. Assume the factor for excess as 1.5.

**607.** How many calories are required to raise 500 g. of a substance of specific heat 0.5 from + 15° C. to + 37° C.?

**608.** How many g. of hot water at + 100° C. must be poured into 3 l. of cold water at + 4° C. to warm it to + 20° C.?

**609.** When 200 g. of hot water at + 80° C. are poured into a pail of water at + 14° C., the temperature of the mixture becomes + 20° C. How many g. of cold water must there have been in the pail at first?

**610.** If 80 g. of water at + 100° C. are poured into 80 g. of water at + 10° C., what will be the temperature of the mixture?

**611.** If 500 g. of water at + 90° C. are poured into 600 g. of water at + 30° C., what will be the resulting temperature?

**612.** One Kg. of copper at + 100° C., when plunged into 600 g. of water at + 10° C., raises the temperature of the water to + 22° C. Find the specific heat of copper.

**613.** Find the water equivalent, or thermal capacity, of a brass calorimeter weighing 92 g.

**614.** How many g. of mercury at  $+98^{\circ}\text{C.}$  must be poured into 100 g. of water to raise its temperature from  $+5^{\circ}\text{C.}$  to  $+18^{\circ}\text{C.}$ ?

**615.** How many calories of heat are required to raise the temperature of (a) 5 g. of water  $+10^{\circ}\text{C.}$ ; (b) 8 g. of zinc  $+20^{\circ}\text{C.}$ ?

**616.** How many calories of heat are given out (a) when 2 Kg. of water cools  $+90^{\circ}\text{C.}$ ; (b) when 700 g. of copper cools from  $+250^{\circ}\text{C.}$  to  $+140^{\circ}\text{C.}$ ?

**617.** If 500 g. of water at  $+5^{\circ}\text{C.}$  and 500 g. of mercury at  $0^{\circ}\text{C.}$  are each given the same quantity of heat, how hot will the mercury become when the water has been heated to  $+10^{\circ}\text{C.}$ ?



## CHAPTER XIV

### A Progressive Series of Problems based on Equations taken from a recent text-book on General Inorganic Chemistry

1. If 63 g. of sodium react with hydrogen monoxide, what is the weight of gas evolved?
2. If 32 g. of muriatic acid are treated with zinc, how many g. of salt are produced?
3. Zinc is boiled with caustic soda solution and 10 l. of a gas are given off. Find weight of zinc and caustic soda used.
4. A solution containing 27 g. NaOH is heated with an excess of zinc. Find weight and volume of gas produced.
5. What weight of oxygen and what other component is required to make 100 g. of  $\text{BaO}_2$ ?
6. Sodium peroxide, when added to water, liberates 10 l. of oxygen at  $+6^\circ \text{C}$ . and 662 mm. Find weight of NaOH produced.
7. What volume of ozone can be made from 300 g. of oxygen?
8. What weight of water is required to decompose completely 23 g. of  $\text{Na}_2\text{O}_2$ ?
9. What weight of NaOH can be made from 200 g. of sodium monoxide?

10. On heating 392 g. of copper hydroxide, what weights of products do you get?

11. Into how many g. of the resultant gases do 222 l. of HCl decompose?

12. In the synthesis of 100 g. of table salt, what weights of the components are used and what volume of the gaseous constituent is needed at  $\frac{1}{2}$  atmospheric pressure and a temperature of  $+10^{\circ}\text{C}.$ ?

13. What volume of HCl is needed to produce 30 g. of  $\text{MnCl}_2$ ?

14. What weight and volume of oxygen will be needed to liberate 102 m.<sup>3</sup> of chlorine from muriatic acid?

15. We need 2 tons of bromine. What weight of chlorine is required and how much NaCl will be produced?

16. If 110 g. of NaI are decomposed by chlorine, what are the weights of the products, and what is the volume of chlorine at  $+300^{\circ}\text{C}.$  and 663 mm.?

17. If 222 l. of chlorine are dissolved in water and exposed to the sun, what weights of materials will be left after complete decomposition?

18. How much KOH would be needed to make 79 g. of KCl?

19. Fluorine and water gave 63 l. of HF at  $0^{\circ}\text{C}.$  and 771 mm. Find volume of fluorine used at  $-10^{\circ}\text{C}.$  and 621 mm.

20.  $\text{NaCl} + \text{H}_2\text{SO}_4$  will give either sodium sulphate or sodium hydrogen sulphate according to the temperature. If 100 g. of  $\text{H}_2\text{SO}_4$  are used in either case, what weight of salt will be required?

21. NaBr will give what volume and weight of HBr when treated with 16 g. of  $\text{H}_3\text{PO}_4$ ?

22.  $\text{PBr}_3$  with 100 g. of  $\text{H}_2\text{O}$  will give what weights and what volume of gaseous product?

23. Of phosphorus 10 lb., of bromine 6 lb., and of water 1 lb. are mixed. After complete reaction, what weights of products and of excess do you get?

24. If 20 g. of  $\text{HKF}_2$  decompose, what weights of what substances result?

25. What weight of fluorspar will give 10 lb. of  $\text{CaSO}_4$  when treated with oil of vitriol? What volume of gas will result at  $-40^\circ \text{C}$ . and 2 atmospheres pressure?

26. An iron ore is 60 % silica. What weight of sample was taken if it requires 20 l. of HF to decompose it?

27. The decomposition of 2 lb. LiCl will give how many l. of chlorine at  $-1^\circ \text{C}$ . and 600 mm.?

28. To make 1 Kg. of potassium, what weight of carbon and  $\text{K}_2\text{CO}_3$  will be needed, and what volume of gas will be evolved?

29. What weight of ammonium salt is required by 13 l. of nitrogen at  $+112^\circ \text{C}$ . and 300 mm.?

30. What weight of  $\text{NH}_4\text{NO}_3$  will yield 21 l. of laughing gas at standard conditions?

31. In the synthesis of 30 g. of ammonia, what volume of the components will be needed at  $+13^\circ \text{C}$ . and 900 mm.?

32. What weight of water is required by 10 g. of  $\text{Mg}_3\text{N}_2$  for complete decomposition, and what volume of gas will be evolved?

33.  $\text{NH}_4\text{OH}$ , on breaking up, gives 3 l. of  $\text{NH}_3$  at  $0^\circ \text{C}$ . and 760 mm. Find weight of hydroxide used.

34. Sal-ammoniac is treated with 10 g. of KOH. Find weights of resulting compounds.

35. If 20 g. of potassium and enough ammonia interact, what weight and volume of hydrogen is produced?

36. What weight of salt is given by 300 cc. of  $\text{HCl} + \text{NH}_3$ ?

37. Lime water treated with 10 l. of  $\text{CO}_2$  at standard conditions will give what weight of precipitate?

38. How much acid calcium carbonate can be produced from 1 lb. of slaked lime and sufficient  $\text{CO}_2$ ?

39.  $\text{Al}_4\text{C}_3$  on treatment with 12 Kg. of water will give what volume of  $\text{CH}_4$  and what weight of precipitate?

40. To produce 3000 cc. of  $\text{CH}_4$ , what weight of sodium acetate would be needed?

41. What volume of oxygen would be needed to burn 300 cc. of marsh gas?

42. If 2 l. of oxygen are heated with carbon, what volume of gas is produced at  $\frac{1}{2}$  atmospheric conditions?

43. If 100 lb. of chalk are treated with  $\text{HCl}$ , what weight of water will be produced?

44. Magnesium is burned in a flask containing 20 l. of choke damp at  $0^\circ \text{C}$ . and 760 mm. Find weight of magnesium used and of carbon liberated.

45. To produce 20 l. of  $\text{CO}$ , what weights of substances are needed?

46. Carbon is heated with 100 g. of oxygen. Find the weight of the product.

47. How much  $\text{H}_2\text{O}$  and  $\text{CO}_2$  will be needed to produce a gram molecule of formic acid?

48. One ton of coke and steam reacting will give what volume of gas at  $+10^{\circ}\text{C}$ . and 777 mm.?

49. If 800 cc. of CO are passed over heated CuO, what weight of copper is left?

50. In the reduction of 100 tons of hematite, what weight of CO will be needed and what weight of metal will result?

51.  $\text{K}_2\text{S}_5 + 100\text{ g. of HCl}$  will give what weight of sulphur; what volume of gas?

52.  $\text{Ca}_3(\text{PO}_4)_2 + 3\text{ SiO}_2 + 5\text{ C} = 3\text{ CaSiO}_3 + 5\text{ CO} + 2\text{ P}$ . Find weights of products when 3 Kg. of C. are used; find volume of CO at  $-40^{\circ}\text{C}$ . and 1000 mm.

53. Arsenopyrite is roasted with 10 g. of oxygen. Find volume of gas evolved and  $\text{As}_2\text{O}_3$  produced.

54. In the reduction of 200 g. of poisonous flour, what weight of metal is produced?

55. What weights of materials will be needed to produce 100 lb. of antimony?

56. One Kg. sodium reacts on  $\text{BaCl}_2$ . Find weight of common salt produced.

57. We need 200 g. of boron; what weight of the oxide and sodium will be needed?

58. What weight of magnesium must be used to reduce 10 Kg. of  $\text{B}_2\text{O}_3$ ?

59. What weight of aluminum can be made from the double halogen salt of aluminum when treated with 100 g. of sodium?

60. In the Goldschmidt alumino-thermic process, what weight of materials must be used to give 100 lb. of iron?

61. If 10 g. of aluminum are treated (a) with  $\text{HCl}$ ; (b) with  $\text{NaOH}$ ; (c) with  $\text{KOH}$ , what is the weight of products in each case?

62. If 300 lb. of sand are heated with carbon, how much silicon will result; what volume of gas at  $+81^\circ \text{C}$ . and  $\frac{1}{4}$  atmosphere?

63. If 100 l. of  $\text{CO}$  are produced in the reduction of  $\text{SiO}_2$  with  $\text{C}$ , what is the weight of metal freed?

64. What volume of hydrogen at 2 atmospheres and  $-10^\circ \text{C}$ . can be made from 300 g. of tin, and  $\text{HCl}$ ?

65. What weight of tin oxide can be made by heating 20 g. of tin in air?

66. If 400 g.  $\text{K}_2\text{SnO}_3$  are made from tin,  $\text{H}_2\text{O}$  and  $\text{KOH}$ , what is the weight of each substance used?

67. What volume of chlorine is needed to make 300 g. of  $\text{SnCl}_4$  from  $\text{SnCl}_2$ ?

68. Galena heated with 1 Kg. of oxygen will give what volume of  $\text{SO}_2$ ; what weight of litharge?

69. What weight of lead heated with air will produce 10 lb. of lead monoxide? Find volume of air used.

70. When 30 g. of litharge and sufficient galena are heated together to produce the metal, what weight of products will they give?

71. If 10 g. of  $\text{HCl}$ , 20 g. of  $\text{NaOH}$  and 30 g. of  $\text{KOH}$  each react on zinc, what in each case is the weight of the product?

72. Hematite is reduced by hydrogen. What weight of iron can be made from 100 g. of ore?

73. If 100 g. of cinnabar are roasted in air, what weight of quicksilver results?

74. Iron and CO interact. Find weight of iron needed to give 100 l. of oxygen.

75. If 600 g. of  $\text{H}_2\text{O}_2$  are made from  $\text{Ba}_2\text{O}_2$ , what weight of oil of vitriol is needed?

76. One l. of ozone with  $\text{H}_2\text{O}_2$  gives what volume of oxygen?

77.  $\text{Ag}_2\text{O}$  and 100 g. of  $\text{H}_2\text{O}_2$  will liberate what weight of oxygen and of silver?

78. What weight of iron sulphide will make 20 l. of  $\text{H}_2\text{S}$ ?

79. Calcium phosphide treated with 100 g. of muriatic acid will liberate what volume of phosphine at  $+1^\circ\text{C}$ . and 766 mm.?

80.  $\text{KOH} + \text{P}_4 + 3\text{H}_2\text{O} = 3\text{KH}_2\text{PO}_2 + \text{PH}_3$ . What weight of KOH and of P are needed to give (a) 100 g. of  $\text{PH}_3$ ; (b) 31 l. of  $\text{PH}_3$  at  $+8^\circ\text{C}$ . and 861 mm.?

81.  $5\text{P}_2\text{H}_4 = 6\text{PH}_3 + \text{P}_4\text{H}_2$ . Find weight of  $\text{P}_4\text{H}_2$  produced when 17 g. of  $\text{PH}_3$  is liberated at  $+13^\circ\text{C}$ . and 750 mm.?

82. Arsenic is made from 3 g. of  $\text{As}_2\text{O}_3$  and carbon. How much carbon is needed?

83.  $\text{SiMg}_2 + 4\text{HCl} = 2\text{MgCl}_2 + \text{SiH}_4$ . If 30 g. of HCl are used, find weights of the other factors in the equation.

84. If 30 g.  $\text{ZnCl}_2$  are made from ZnO, what is its weight?

85.  $3\text{Cl}_2 + \text{Al}_2\text{O}_3 + 3\text{C}$  react. Find weight of  $\text{AlCl}_3$  and volume of carbon monoxide if 10 g. of Cl are used.

86. Zinc is acted on by 20 l. of chlorine. What weight of salt is produced?

87. A lunar caustic solution containing 20 g. is treated with a "salt" solution. Find weight of residue left in solution after filtering.

88. If 100 g. of iron are treated with 600 g. of iodine, what weight of the iron iodide is made?

89. In the following equation, if 1 Kg. of AgBr is used, find the weight of the missing compound:

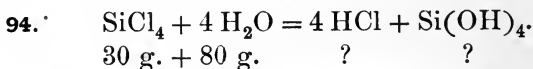


90.  $\text{NaAuCl}_4 + 3\text{Ag} = \text{NaCl} + 3\text{AgCl} + \text{Au}$ . In this equation calculate the weight of gold when 100 g. of silver are used.

91.  $1\text{ g. BCl}_3 + \text{water} = \text{what volume of gas and what weight of B(OH)}_3?$

92. Fire damp and chlorine interact, producing tetrachlormethane and 10 l. of HCl. Find weights of the first two substances.

93.  $100\text{ g. CCl}_4 + \text{H}_2\text{O} = \text{what volume of CO}_2 \text{ at } +33^\circ \text{ C. and } 555\text{ mm.}?$



Find weights of the products and excess.

95.  $\text{SiO}_2$  and HF interact. If 30 g. of  $\text{H}_2\text{O}$  are produced, find the volume of HF used at  $+60^\circ \text{ C.}$  and 760 mm.

96. 1 g. silicon fluoride is passed into an excess of water. What volume of gas and weight of solid is left?

97. What weight of metastannic acid is given by 3 g. of stannic chloride with water?

98. What weights of  $\text{SiF}_4$  and water result in the production of 90 g. of  $\text{H}_2\text{SiF}_6$ ?



99.  $\text{TiCl}_4 + \text{water} = \text{what weight of } \text{TiOCl}_2 \text{ when 2 l. of HCl are given off?}$

100. To produce 30 g. of  $\text{H}_2\text{SnO}_3$ , what weight of  $\text{SnCl}_4$  was used?

101. One l. of lead nitrate solution is treated with 20 g. of salt and a complete precipitation occurs. Find the percentage of lead salt in the solution.

102. What weight and what volume of chlorine is liberated by 100 g. of  $\text{PbO}_2 + \text{HCl}$ ?

103.  $\text{PCl}_3$ ,  $\text{AsCl}_3$ ,  $\text{BiCl}_3$  and  $\text{SbCl}_3 + \text{excess of water} = \text{what weight of the oxychlorides when 4 l. of HCl are liberated in each case?}$

104.  $10 \text{ g. } \text{PCl}_3 + 3 \text{ H}_2\text{O} = 3 \text{ HCl} + ?$

$10 \text{ g. } \text{PCl}_5 + \text{H}_2\text{O} = 2 \text{ HCl} + ?$

$10 \text{ g. } \text{POCl}_3 + 3 \text{ H}_2\text{O} = 3 \text{ HCl} + ?$

$10 \text{ g. } \text{PCl}_5 + 4 \text{ H}_2\text{O} = 5 \text{ HCl} + ?$

In these equations find the weight of the compound formed in each case.

105.  $2 \text{ CuSO}_4 + \text{K}_4\text{Fe}(\text{CN})_6 = \text{Cu}_2\text{Fe}(\text{CN})_6 + ?$

If 100 g. of  $\text{K}_4\text{Fe}(\text{CN})_6$  are taken, what weight of bluestone is used, and what weight of the missing term is produced?

106. Copper heated with 1 m.<sup>3</sup> of air will yield what weight of oxide?

107. 2 Kg. of  $\text{P}_2\text{O}_5$  contain what weight of P and what volume oxygen?

108. A 3 l. flask of O acts on  $\text{ZnS}$ . Find the weight of products.

109. On roasting 800 g. of  $\text{As}_2\text{S}_3$ , what volume of O is needed and what volume of gas is produced?

110. If 100 g. of  $\text{CuSO}_4$  in solution are treated with a solution of  $\text{KOH}$  and the precipitate is heated, what weight of products results?

111. Limestone is heated till all the gas is driven off. It measures 109 l. Calculate the weight of gas and of oxide produced.

112. What weight of oxide and of water is formed by 20 g. of  $\text{B}(\text{OH})_3$ ?

113. Lime + 300 lb. of water = what weight of calcium hydroxide?

114.  $\text{P}_2\text{O}_5$  and  $\text{H}_2\text{O}$  interact and form 100 g. of orthophosphoric acid. Find weight of  $\text{P}_2\text{O}_5$  and volume of  $\text{H}_2\text{O}$  at  $0^\circ \text{C}$ . and 760 mm.

115. What weight and volume of  $\text{H}$  are liberated by 2 Kg. of sodium thrown on water?

116. Ferric chloride + 30 cc. of  $\text{NaOH}$  solution (50%) will yield what weight of precipitate?

117. Sulphuric anhydride + a ton of water produce what weight and volume of acid? (Sp. gr. of  $\text{H}_2\text{SO}_4 = 1.84$ .)

118. What weight of  $\text{Na}_2\text{O}$  and of  $\text{H}_2\text{O}$  are required to produce 100 g. of  $\text{NaOH}$ ?

119. What weight of  $\text{NaOH}$  will be required to neutralize 300 cc.  $\text{N}/2 \text{H}_2\text{SO}_4$  solution?

120.  $\text{Na}_2\text{O}$  + 100 g. of water will form what weight of caustic soda?

121. What weight of  $\text{CuS}$  will be precipitated by 27 l. of  $\text{H}_2\text{S}$  at  $+20^\circ \text{C}$ . and 667 mm. from excess of copper solution?

122. Green vitriol +  $(\text{NH}_4)_2\text{S}$  give 100 g. of  $\text{FeS}$ . Find weights of substances used.

**123.** Muriatic acid in excess reacts on 100 g. of FeS. Find volume of gas evolved at  $-13^{\circ}$  C. and 500 mm.

**124.** To slake 1 ton of lime what volume of water at  $0^{\circ}$  C. would be needed, and what weight of  $\text{Ca}(\text{OH})_2$  would be produced?

**125.** From 1000 Kg. of  $\text{Na}_2\text{CO}_3$ , what weight of NaOH can be made?

**126.** To produce 100 l. of oxygen what weight of  $\text{Na}_2\text{O}_2$  would be needed and what volume of  $\text{H}_2\text{O}$  in cc. would be used?

**127.**  $\text{Na}_2\text{SO}_4 + \text{C} =$  what weight of products, if 3 Kg. of carbon are used?

**128.**  $\text{H}_2\text{S}$  and 3 g. of potassium will liberate what volume of gas at  $+20^{\circ}$  C. and 777 mm.?

**129.**  $\text{CuO} + 100$  g. of  $\text{H}_2\text{SO}_4$  will yield what weight of water?

**130.**  $\text{CuCl}_2$  with caustic soda solution containing 50 g. yields what weight of  $\text{Cu}(\text{OH})_2$ ?

**131.** On boiling 300 g. of copper hydroxide with water, what weights of materials result?

**132.**  $\text{CuOH}$  on being heated yields 10 g. of  $\text{Cu}_2\text{O}$ ; what weight of water will be formed?

**133.**  $\text{AuO,OH} + \text{NaOH} = \text{H}_2\text{O} + \text{NaAuO}_2$ . If 41 g. of NaOH are used, what weight of  $\text{NaAuO}_2$  will result?

**134.** A bin of lime is treated with 10 tons of water, which just slakes it. A house is plastered with this lime made into mortar. Find the volume of  $\text{CO}_2$  needed to convert all the mortar into  $\text{CaCO}_3$ .

**135.**  $\text{CaSO}_4$  on being heated with 2 Kg. of carbon yields what weights of materials?

**136.** When 30 g. of  $\text{ZnSO}_4$  are treated with NaOH solution, they will yield (a) what weight of  $\text{Zn(OH)}_2$ ; (b) what weight of compound when NaOH is used in excess?

**137.** Mercurous nitrate with 30 g. of NaOH gives what weight of  $\text{Hg}_2\text{O}$ ?

**138.**  $\text{Hg}_2\text{O}$  on exposure to light yields 30 g. of mercury. Find weight of  $\text{Hg}_2\text{O}$  used and of residue other than Hg left.

**139.**  $\text{H}_2\text{S}$  is passed into a solution containing 100 g. of  $\text{HgCl}_2$ . What volume of gas is used to bring about complete precipitation?

**140.** KI solution containing 30 g. reacts on (a)  $\text{HgNO}_3$  solution; (b)  $\text{Hg(NO}_3)_2$  solution. Find weight of resulting salt in each case.

**141.**  $\text{NH}_4\text{OH}$ , when mixed with 20 g. of  $\text{Al}_2(\text{SO}_4)_3$  in solution, yields how many g. of residue?

**142.**  $\text{Al}_2(\text{SO}_4)_3 + 100$  g.  $(\text{NH}_4)_2\text{S}$  will produce what weight of the sulphide of the metal?

**143.**  $\text{Al}_2\text{S}_3 + \text{excess of water}$  gives 200 g. of  $\text{Al(OH)}_3$ . Find weight of  $\text{Al}_2\text{S}_3$ .

**144.** In the Le Blanc process what weight of materials can be made from 300 Kg. of common salt?

**145.** Sodium sulphide with 200 Kg. of powdered limestone produces what weight of  $\text{CaS}$ ?

**146.** From 10,000 l. of  $\text{NH}_3 + \text{sufficient CO}_2$  and water, how many Kg. of sodium dicarbonate may be produced?

**147.** Washing soda + water and 3000 l. of  $\text{CO}_2$  at  $-8^\circ \text{C}$ . and 900 mm. will produce what weight of the dry product?

**148.** Dicarbonate of soda with 30 l. of HCl will generate what volume of gaseous product?

**149.** Silver nitrate with 21 g. of  $\text{Na}_2\text{CO}_3$  gives what weight of precipitate?

**150.** Washing soda reacting on 1 Kg. of sugar of lead will throw down what weight of residue in solution?

**151.**  $3 \text{PbCO}_3 + \text{H}_2\text{O} = \text{Pb}_3(\text{CO}_3)_2(\text{OH})_2 + \text{CO}_2$ . If 500 l. of  $\text{CO}_2$  are liberated, what is the weight of basic salt produced?

**152.** What volume of HF will be needed to use up 20 g. of quartz, and what weight of gas will be produced?

**153.**  $\text{Na}_4\text{SiO}_4$  is made from  $\text{SiO}_2$  and 300 g. of  $\text{Na}_2\text{O}$ . What weight of  $\text{Na}_4\text{SiO}_4$  was produced?

**154.**  $\text{K}_4\text{SiO}_4$ , on treatment with 200 l. of HCl, produces what weight of orthosilicic acid and of KCl?

**155.** Sodium sulphide + 100 g. of  $\text{SnS}_2 = \text{Na}_2\text{SnS}_3$ . Find weight of  $\text{Na}_2\text{S}$ .

**156.** Copper + 2 Kg. of aqua fortis will yield what weight of  $\text{Cu}(\text{NO}_3)_2$ , and what volume of nitric oxide at  $+30^\circ \text{C}$ . and 900 mm.?

**157.**  $\text{As}_2\text{O}_3 + 2 \text{HNO}_3 + 2 \text{H}_2\text{O} = 2 \text{H}_3\text{AsO}_4 + ?$   
If 100 g. of  $\text{As}_2\text{O}_3$  are used, find weight and volume of gas not given in equation.

**158.** To make 10 g. of nitrous acid, what weights of  $\text{N}_2\text{O}_3$  and  $\text{H}_2\text{O}$  are needed?

**159.** If 37 l. of oxygen are mixed with 39 l. of nitric oxide, what volume of a new gas results and what volume of residue is left?

**160.** Lead nitrate on being heated yields 30 l. of oxygen. Find weight of lead nitrate heated.

161. How much  $\text{HNO}_3$  would 100 Kg. of  $\text{N}_2\text{O}_5$  make with water?

162. Chili saltpeter treated with 300 Kg. of  $\text{H}_2\text{SO}_4$  will yield what weight of  $\text{HNO}_3$ ?

163. What volume of chlorine will be liberated from 100 g. of  $\text{HCl}$  and enough  $\text{HNO}_3$  to make aqua regia; and with what weight of gold will this unite?

164. Given 300 g. of  $\text{AuCl}_3$ , what weight of  $\text{SnCl}_2$  will be required to precipitate all the gold?

165. What volume of  $\text{HNO}_3$  (sp. gr. 1.42) will be needed to dissolve 31 g. of silver and what volume of gas will be evolved?

166.  $\text{KCl}$  and  $\text{NaNO}_3$  are allowed to act on each other; 300 Kg. of  $\text{KNO}_3$  result. What weights of the salts were used?

167. What weight of  $\text{H}_3\text{PO}_3$  will yield 17 l. of  $\text{PH}_3$ ?

168. From 75 g. of  $\text{P}_2\text{O}_5$  + water, what weight of orthophosphoric acid results?

169. A mass of apatite is treated with 100 tons of  $\text{H}_2\text{SO}_4$ ; what weight of  $\text{CaH}_4(\text{PO}_4)_2$  will be formed?

170. One ton of  $\text{Ca}_3(\text{PO}_4)_2$  on treatment with acid will produce what weight of  $\text{CaSO}_4$  and of  $\text{CaHPO}_4$ ?

171.  $\text{P}_4 + 3\text{NaOH} + 3\text{H}_2\text{O} = 3\text{NaH}_2\text{PO}_2 + \text{PH}_3$ . If 300 g. of phosphorus are used, what are the weights of the other members of the above equation, and what is the volume of the gas at  $-31^\circ\text{C}$ . and 599 mm.?

172.  $\text{H}_3\text{AsO}_4$  is made from  $\text{As}_2\text{O}_5$  and 10 g. of water. Find weight of materials used and produced.

173.  $\text{Na}_2\text{S}_2\text{O}_3 + 1\text{Kg. HCl} =$  what weight of sulphur and what volume of  $\text{SO}_2$ ?

174.  $\text{CuO}$  and 750 g. of  $\text{H}_2\text{SO}_4$  produce what weights of products?

175. One g. of  $\text{Na}_2\text{CO}_3$  and 1 g. of  $\text{BaCl}_2$  are separately treated with  $\text{H}_2\text{SO}_4$ . Find weights of products.

176.  $\text{PbS}$  is roasted with oxygen. If a ton of  $\text{PbSO}_4$  is produced, what volume of oxygen has been used at 1 atmosphere pressure and  $+26^\circ \text{C}.$ ?

177.  $\text{Se} + 3 \text{Cl}_2 + 4 \text{H}_2\text{O} = 1 \text{ Kg. of } \text{H}_2\text{SeO}_4 + 6 \text{HCl}.$  Find weights of members on left side of equation and volume of  $\text{HCl}$  produced.

178.  $2 \text{Cr}(\text{OH})_2 = 21 \text{ g. of } \text{Cr}_2\text{O}_3 + \text{H}_2\text{O} + \text{H}_2.$  Calculate the weights of solids in equation and volume of gas.

179.  $\text{CrCl}_3 + 20 \text{ g. of caustic soda}$  produce what weight of salt and of  $\text{Cr}(\text{OH})_3$ ?

180. One Kg. of  $\text{Cr}(\text{OH})_3 =$  what weight of  $\text{CrO}$ ,  $\text{OH}$  and of  $\text{H}_2\text{O}$ ?

181. On heating 100 g.  $\text{CrO}_3$ , what weight of  $\text{Cr}_2\text{O}_3$  do you get and how many  $\text{m.}^3$  of  $\text{O}$ ?

182.  $\text{K}_2\text{CrO}_4$  is decomposed with 1 Kg. of  $\text{H}_2\text{SO}_4$ . Find weight of  $\text{K}_2\text{CrO}_4$  used and of  $\text{K}_2\text{Cr}_2\text{O}_7$  produced.

183.  $\text{K}_2\text{Cr}_2\text{O}_7$  is treated with 30 g. of  $\text{KOH}$  in solution. Find weight of material used and produced.

184.  $\text{Na}_2\text{Cr}_2\text{O}_7$  is changed by 10 g. of  $\text{KCl}$  into  $\text{K}_2\text{Cr}_2\text{O}_7$ . Find weight of  $\text{NaCl}$  produced.

185. On heating 1 Kg. of  $\text{K}_2\text{Cr}_2\text{O}_7$ , what weights of normal chromate,  $\text{Cr}_2\text{O}_3$ , and volume of oxygen do you get?

186. Oil of vitriol with 376 g. of  $\text{K}_2\text{Cr}_2\text{O}_7$  produces what weights of materials and what volume of gas at  $-22^\circ \text{C.}$  and 941 mm.?

187.  $\text{Cr}_2(\text{SO}_4)_3 + 23 \text{ g. of } (\text{NH}_4)_2\text{S}$  will produce what weight of  $\text{Cr}_2\text{S}_3$  and of ammonium sulphate?

188.  $\text{Cr}_2\text{S}_3$ , on treatment with 99 cc. of  $\text{H}_2\text{O}$  at  $0^\circ \text{C}$ . and 760 mm., yields what weight of substances?

189. Sugar of lead + 10 g. of  $\text{K}_2\text{Cr}_2\text{O}_7$  = how much precipitate? A lead salt + 32 g. of  $\text{K}_2\text{CrO}_4$  produces what weight of lead chromate?

190. One Kg. of corrosive sublimate is made from what weights of  $\text{HgO}$  and chlorine?

191. To make 30 g. of  $\text{HOCl}$ , how much  $\text{Cl}_2\text{O}$  and  $\text{H}_2\text{O}$  must be used?

192.  $\text{Cl}_2 + \text{H}_2\text{O} = \text{HCl} + \text{HOCl}$ . If 21 l. of chlorine at  $+8^\circ \text{C}$ . and 600 mm. are used, find volume of  $\text{HCl}$  produced at standard conditions.

193.  $\text{HgO}$ , water, and 333 l. of chlorine are placed in a vessel. How many g. of  $\text{HgCl}_2$  and of  $\text{HOCl}$  were produced?

194. Through a  $\text{KOH}$  solution is passed 13 l. of chlorine. Find the weight of  $\text{KOCl}$  made.

195. If 3 tons of slaked lime are treated with chlorine, what is the weight of bleaching powder produced?

196. Given 25 g. of  $\text{HOCl}$ , what volumes of  $\text{HCl}$  and of  $\text{O}$  are produced when it is exposed to sunlight?

197.  $\text{HOCl} + 3 \text{ g. of } \text{HCl}$  give what weight of chlorine and of water?

198.  $\text{CaCl}(\text{OCl}) + 8 \text{ g. of } \text{H}_2\text{SO}_4$  = what weight of  $\text{CaSO}_4$  and of  $\text{HOCl}$ ?

199.  $2 \text{ CaCl}(\text{OCl}) + \text{H}_2\text{O} + \text{CO}_2 = \text{CaCO}_3 + \text{CaCl}_2 + 2 \text{ HOCl}$ . If 13 l. of  $\text{CO}_2$  are used, find weight in g. of resulting substances.



200. When 13 g. of  $\text{NH}_3$  react on  $\text{NaBrO}$ , what volume of nitrogen is given off?

201.  $3 \text{NaBrO} + 100 \text{ g. CO}(\text{NH}_2)_2 =$  what weight of  $\text{NaBr}$ ,  $\text{H}_2\text{O}$ ,  $\text{N}$ , and  $\text{CO}_2$ ?

202.  $3 \text{HOCl} = \text{HOClO}_2 + 2 \text{HCl}$ . If 41 l. of  $\text{HCl}$  are produced, what is the weight of  $\text{HOCl}$  used?

203. Should 30 g. of  $\text{KOC}$  break up, find weight of  $\text{KOC}$  and of  $\text{KCl}$  produced.

204. In the making of  $\text{KClO}_3$ , 100 l. of chlorine were passed through a solution containing 300 g. of  $\text{KOH}$ . Find the weight of  $\text{KClO}_3$  made and of the substance in excess.

205.  $\text{Ca}(\text{ClO}_3)_2 + 100 \text{ g. of KCl} =$  what weight of  $\text{CaCl}_2$  and of  $\text{KClO}_3$ ?

206. One Kg. of barium chlorate is treated with  $\text{H}_2\text{SO}_4$  in excess. Find weight of precipitate and of  $\text{HClO}_3$ .

207.  $\text{HClO}_3 + 5 \text{ g. of HCl} =$  what weight of  $\text{H}_2\text{O}$  and of chlorine?

208. To make 100 g. of  $\text{HClO}_3$ , what weights of  $\text{Cl}_2\text{O}_5$  and of water are needed?

209.  $\text{Cl}_2\text{O}_4 + 30 \text{ g. H}_2\text{O} =$  how many g. of  $\text{HClO}_3$  and of  $\text{HClO}_2$ ?

210. We need 80 g. of  $\text{HClO}_2$ . How much  $\text{Cl}_2\text{O}_3$  must be dissolved in water to produce it?

211. Should one need to make 30 g. of  $\text{HIO}_3$ , what weight of  $\text{I}_2\text{O}_5$  and of  $\text{H}_2\text{O}$  are needed?

212.  $2 \text{HIO}_3 + 5 \text{SO}_2 + 4 \text{H}_2\text{O} = 5 \text{H}_2\text{SO}_4 + \text{I}_2$ . To produce 30 g. of iodine what volume of  $\text{SO}_2$  at  $-9^\circ \text{C}$ . and 861 mm. should be used?

213.  $2 \text{HClO}_3 = \text{HClO}_2 + \text{HClO}_4$ . Should 20 g. of  $\text{HClO}_3$  be used, what weight of  $\text{HClO}_2$  will result?

214.  $\text{Ba}(\text{ClO}_4)_2 + 10 \text{ cc. of } \text{H}_2\text{SO}_4$  (sp. gr. = 1.84) will produce what weight of residue and of  $\text{HClO}_4$ ?

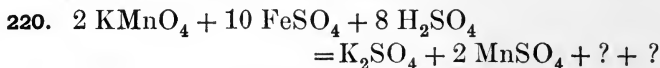
215. If 77 g. of  $\text{KClO}_3$  are heated just to fusion, what weights of  $\text{KClO}_4$ ,  $\text{KCl}$ , and  $\text{O}$  will result?

216. 1 g.  $\text{HClO}_4$  on treatment with iodine yields how many g. of  $\text{HIO}_4$  and  $\text{Cl}$ ?

217. To make 39 g. of  $\text{Mn}(\text{OH})_2$  what weight of  $\text{MnCl}_2$  must be taken and how many cc. of a 40 %  $\text{NaOH}$  solution will be needed?

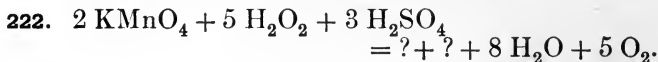
218.  $\text{Mn}_2(\text{SO}_4)_3 + 90 \text{ cc. of } \text{NaOH}$  (25 % solution) will yield how many g. of  $\text{Mn}(\text{OH})_3$  and of  $\text{Na}_2\text{SO}_4$ ?

219. To produce 21 l. of oxygen, what weights of  $\text{KMnO}_4$  and of  $\text{H}_2\text{SO}_4$  are required?

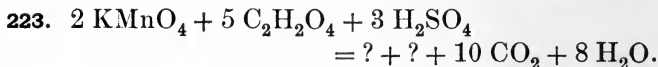


Should 300 g. of  $\text{KMnO}_4$  be used, find weights of missing terms in the above equation.

221. To make 31 g. of  $\text{H}_2\text{SO}_4$  what weights of  $\text{KMnO}_4$ ,  $\text{SO}_2$ , and  $\text{H}_2\text{O}$  are required?



If 13 g. of  $\text{H}_2\text{O}_2$  are used, what weights of missing members of equation and l. of oxygen are produced?



If 20 g. of  $\text{CO}_2$  are produced, calculate the weight of  $\text{KMnO}_4$  used and of missing factors in equation.

224. 10 g. manganese chloride with  $(\text{NH}_4)_2\text{S}$  yields how many g. of  $\text{NH}_4\text{Cl}$  and of  $\text{MnS}$ ?

225. Ferric sulphate with 300 g. of caustic soda in solution produces what mass of ferric hydroxide?

226. From 80 g. of ferrous sulphate +  $(\text{NH}_4)_2\text{S}$  what mass of  $\text{FeS}$  will result?

227. To make 3 tons of  $\text{CaC}_2$  what weights of lime and C are needed?

228. A million m.<sup>3</sup> of  $\text{C}_2\text{H}_2$  are required. How many Kg. of materials will be used and what weight of residue will be left?

229.  $\text{BN} + 3 \text{H}_2\text{O} = \text{B}(\text{OH})_3 + \text{NH}_3$ . To produce 80 cc. of  $\text{NH}_3$  what weight of BN must be taken?

230.  $\text{NaNH}_2 + 31 \text{ cc. of H}_2\text{O}$  will give what weight of  $\text{NaOH}$  and what volume in l. of  $\text{NH}_3$  at + 31° C. and 800 mm. pressure?

231. Mercuric cyanide on being heated breaks up into 3 g. of Hg and  $(\text{CN})_2$ ; what weight was heated?

232. Potassium cyanide on treatment with 2 g.  $\text{H}_2\text{SO}_4$  gives what volume of  $\text{HCN}$  at + 17° C. and 770 mm.?

233. From 2 Kg. of  $\text{CaCN}_2 + \text{H}_2\text{O}$  how many g. of  $\text{Ca}(\text{OH})_2$  and of  $\text{H}_2\text{CN}_2$ ?

234.  $\text{K}_4\text{Fe}(\text{CN})_6$  is reduced with 30 g. of K. What weight of Fe and of KCN are left?

235. Litharge + 1 g. of KCN = what weight of Pb and of KCNO?

236. KCN and 3 g. of  $\text{AgNO}_3$  will give what mass of saltpeter and of  $\text{AgCN}$ ?

237.  $3 \text{K}_4\text{Fe}(\text{CN})_6 + 4 \text{FeCl}_3 = \text{Prussian blue} + 12 \text{KCl}$ . Should 8 g. of  $\text{FeCl}_3$  be used, find the weight of Prussian blue produced.

238.  $2 \text{K}_3\text{Fe}(\text{CN})_6 + 3 \text{FeSO}_4 = 3 \text{K}_2\text{SO}_4 + \text{Turnbull's blue}$ . What weight of Turnbull's blue can be made from 81 g. of  $\text{FeSO}_4$ ?



# APPENDIX

## I.—INTERNATIONAL ATOMIC WEIGHTS, 1911

	Symbol	Atomic Weight		Symbol	Atomic Weight
Aluminium . . . . .	Al	27.1	Molybdenum . . . . .	Mo	96.0
Antimony . . . . .	Sb	120.2	Neodymium . . . . .	Nd	144.3
Argon . . . . .	A	39.88	Neon . . . . .	Ne	20.2
Arsenic . . . . .	As	74.96	Nickel . . . . .	Ni	58.68
Barium . . . . .	Ba	137.37	Nitrogen . . . . .	N	14.01
Bismuth . . . . .	Bi	208.0	Osmium . . . . .	Os	190.9
Boron . . . . .	B	11.0	Oxygen . . . . .	O	16.00
Bromine . . . . .	Br	79.92	Palladium . . . . .	Pd	106.7
Cadmium . . . . .	Cd	112.40	Phosphorus . . . . .	P	31.04
Cæsium . . . . .	Cs	132.81	Platinum . . . . .	Pt	195.2
Calcium . . . . .	Ca	40.09	Potassium . . . . .	K	39.10
Carbon . . . . .	C	12.0	Praseodymium . . . . .	Pr	140.6
Cerium . . . . .	Ce	140.25	Radium . . . . .	Ra	226.4
Chlorine . . . . .	Cl	35.46	Rhodium . . . . .	Rh	102.9
Chromium . . . . .	Cr	52.0	Rubidium . . . . .	Rb	85.45
Cobalt . . . . .	Co	58.97	Ruthenium . . . . .	Ru	101.7
Columbium . . . . .	Cb	93.5	Samarium . . . . .	Sa	150.4
Copper . . . . .	Cu	63.57	Scandium . . . . .	Sc	44.1
Dysprosium . . . . .	Dy	162.5	Selenium . . . . .	Se	79.2
Erbium . . . . .	Er	167.4	Silicon . . . . .	Si	28.3
Europium . . . . .	Eu	152.0	Silver . . . . .	Ag	107.88
Fluorine . . . . .	F	19.0	Sodium . . . . .	Na	23.00
Gadolinium . . . . .	Gd	157.3	Strontium . . . . .	Sr	87.63
Gallium . . . . .	Ga	69.9	Sulphur . . . . .	S	32.07
Germanium . . . . .	Ge	72.5	Tantalum . . . . .	Ta	181.0
Glucinum . . . . .	Gl	9.1	Tellurium . . . . .	Te	127.5
Gold . . . . .	Au	197.2	Terbium . . . . .	Tb	159.2
Helium . . . . .	He	3.99	Thallium . . . . .	Tl	204.0
Hydrogen . . . . .	H	1.008	Thorium . . . . .	Th	232.4
Indium . . . . .	In	114.8	Thulium . . . . .	Tm	168.5
Iodine . . . . .	I	126.92	Tin . . . . .	Sn	119.0
Iridium . . . . .	Ir	193.1	Titanium . . . . .	Ti	48.1
Iron . . . . .	Fe	55.85	Tungsten . . . . .	W	184.0
Krypton . . . . .	Kr	82.92	Uranium . . . . .	U	238.5
Lanthanum . . . . .	La	139.0	Vanadium . . . . .	V	51.06
Lead . . . . .	Pb	207.10	Xenon . . . . .	Xe	130.2
Lithium . . . . .	Li	6.94	Ytterbium		
Lutecium . . . . .	Lu	174.0	(Neo-ytterbium) . . . . .	Yb	172.0
Magnesium . . . . .	Mg	24.32	Yttrium . . . . .	Yt	89.0
Manganese . . . . .	Mn	54.93	Zinc . . . . .	Zn	65.37
Mercury . . . . .	Hg	200.0	Zirconium . . . . .	Zr	90.6

## II.—THE PERIODIC ARRANGEMENT OF THE ELEMENTS

According to Mendelejeff \*

On the basis of  $O = 16$ 

Period	Group O	Group I RH $R_2O$	Group II $RH_2$ $RO(R_2O_2)$	Group III $KH_3$ $R_2O_3$	Group IV $RH_4$ $RO_2(R_2O_4)$	Group V $RH_3$ $R_2O_5$	Group VI $RH_2$ $RO_3(R_2O_6)$	Group VII RH $R_2O_7$	Group VIII $RO_4(K_2O_8)$
1									
2	He=3.99	H=1.008	Be=9.1	B=11	C=12	N=14.01	O=16	F=19	
3	Ne=20.2	Li=6.94	Mg=24.32	Al=27.1	Si=28.3	P=31	S=32.07	Cl=35.46	
4	A=39.88	Na=23	Ca=40.09	Sc=44.1	Ti=48.1	V=51.06	Cr=52	Mn=54.93	Fe=55.85, Co=58.97, Ni=58.68
5		K=39.1	Zn=65.37	Ga=69.9	Ge=72.5	As=74.96	Se=79.2	Br=79.92	
6	Kr=82.92	Cu=63.57	Sr=87.63	Yt=89	Zr=90.6	Cb=93.5	Mo=96	— =100	Ru=101.7, Rh=102.9, Pd=106.7
7		Ag=107.88	Cd=112.4	In=114.8	Sn=119	Sb=120.2	Te=127.5	I=126.92	
8	Xe=130.2		Ba=137.37	La=139	Ce=140.25	(Pr=140.6)	(Nd=144.8)	— =149	Sm=150.4, Eu=152, Gd=157.3
9			—	Er=167.4	—	Yb=172	—	—	
10			—	—	—	Ta=181	W=184.0	—	Os=190.9, Ir=193.1, Pt=195.2
11	Au=197.2		Hg=200	Tl=204	Pb=207.1	Bi=208	—	—	
12			Ra=226.4	—	Th=232.4	—	U=238.5	—	

Some of the rare-earth metals (Vc=117, Tb=159.2, Dy=162.5, Ho=165, Tm=171, Lu=174, etc.) not placed.

\* Revised by the senior author and given in his *Organic Chemistry*, Boston, 1910.

## III.—THE METRIC SYSTEM

The fundamental unit of the metric system is the **Meter** (the unit of length). From this the units of mass (**Gram**) and capacity (**Liter**) are derived. All other units are the decimal subdivisions or multiples of these. These three units are simply related, so that for all practical purposes the volume of one kilogram of water (one liter) is equal to one cubic decimeter.

PREFIXES		MEANING		UNITS
<b>Milli-</b>	= one thousandth	$\frac{1}{1000}$	<b>.001</b>	<b>Meter</b> for length <b>Gram</b> for mass <b>Liter</b> for capacity
<b>Centi-</b>	= one hundredth	$\frac{1}{100}$	<b>.01</b>	
<b>Deci-</b>	= one tenth	$\frac{1}{10}$	<b>.1</b>	
	unit = one		<b>1.</b>	
<b>Deka-</b>	= ten	$\frac{10}{1}$	<b>10.</b>	
<b>Hecto-</b>	= one hundred	$\frac{100}{1}$	<b>100.</b>	
<b>Kilo-</b>	= one thousand	$\frac{1000}{1}$	<b>1000.</b>	

The metric terms are formed by combining the words "Meter," "Gram," and "Liter" with the six numerical prefixes.

**Length**

10 milli-meters	mm. = 1 centi-meter	cm.
10 centi-meters	= 1 deci-meter	dm.
10 deci-meters	= 1 <b>Meter</b> (about 40 inches)	m.
10 <b>meters</b>	= 1 deka-meter	dkm.
10 deka-meters	= 1 hecto-meter	hm.
10 hecto-meters	= 1 kilo-meter (about $\frac{5}{8}$ mile)	km.

**Mass**

10 milli-grams	mg. = 1 centi-gram	cg.
10 centi-grams	= 1 deci-gram	dg.
10 deci-grams	= 1 <b>Gram</b> (about 15 grains)	g.
10 <b>grams</b>	= 1 deka-gram	dkg.
10 deka-grams	= 1 hecto-gram	hg.
10 hecto-grams	= 1 kilo-gram (about 2 pounds)	kg.

**Capacity**

10 milli-liters	ml. = 1 centi-liter	cl.
10 centi-liters	= 1 deci-liter	dl.
10 deci-liters	= 1 <b>Liter</b> (about 1 quart)	l.
10 <b>liters</b>	= 1 deka-liter	dkl.
10 deka-liters	= 1 hecto-liter (about a barrel)	hl.
10 hecto-liters	= 1 kilo-liter	kl.

The square and cubic units are the squares and cubes of the linear units.  
The ordinary unit of land area is the "Hectare" (about  $2\frac{1}{2}$  acres).

**EQUIVALENTS****1 Meter = 39.37 Inches**

Legal equivalent adopted by Act of Congress, July 28, 1866

**Length**

Centimeter	=	0.3937	inch
Meter	=	3.28	feet
Meter	=	1.094	yards
Kilometer	=	0.621	statute mile
Kilometer	=	0.5396	nautical mile
Inch	=	2.540	centimeters
Foot	=	0.305	meter
Yard	=	0.914	meter
Statute mile	=	1.61	kilometers
Nautical mile	=	1.853	kilometers

**Area**

Sq. centimeter	=	0.155	sq. inch
Sq. meter	=	10.76	sq. feet
Sq. meter	=	1.196	sq. yards
Hectare	=	2.47	acres
Sq. kilometer	=	0.386	sq. mile
Sq. inch	=	6.45	sq. centimeters
Sq. foot	=	0.0929	sq. meter
Sq. yard	=	0.836	sq. meter
Acre	=	0.405	hectare
Sq. mile	=	2.59	sq. kilometers

**Volume**

Cu. centimeter	=	0.0610	cu. inch
Cu. meter	=	35.3	cu. feet
Cu. meter	=	1.308	cu. yards
Cu. inch	=	16.39	cu. centimeter
Cu. foot	=	0.0283	cu. meter
Cu. yard	=	0.765	cu. meter



**EQUIVALENTS**—*Continued***Capacity**

Milliliter	=	0.0338	U. S. liq. ounce
Milliliter	=	0.2705	U. S. apoth. dram
Liter	=	1.057	U. S. liq. quarts
Liter	=	0.2642	U. S. liq. gallon
Liter	=	0.908	U. S. dry quart
Dekaliter	=	1.135	U. S. pecks
Hectoliter	=	2.838	U. S. bushels
U. S. liq. ounce	=	29.57	milliliters
U. S. apoth. dram	=	3.70	milliliters
U. S. liq. quart	=	0.946	liter
U. S. dry quart	=	1.101	liters
U. S. liq. gallon	=	3.785	liters
U. S. peck	=	0.881	dekaliter
U. S. bushel	=	0.3524	hectoliter

**Weight**

Gram	=	15.43	grains
Gram	=	0.772	U. S. apoth. scruple
Gram	=	0.2572	U. S. apoth. dram
Gram	=	0.0353	avoir. ounce
Gram	=	0.03215	troy ounce
Kilogram	=	2.205	avoir. pounds
Kilogram	=	2.679	troy pounds
Metric ton	=	0.984	gross or long ton
Metric ton	=	1.102	short or net tons
Grain	=	0.0648	gram
U. S. apoth. scruple	=	1.296	grams
U. S. apoth. dram	=	3.89	grams
Avoir. ounce	=	28.35	grams
Troy ounce	=	31.10	grams
Avoir. pound	=	0.4536	kilogram
Troy pound	=	0.373	kilogram
Gross or long ton	=	1.016	metric tons
Short or net ton	=	0.907	metric ton

## Mensuration Rules

Area of triangle	$= \frac{1}{2} (\text{base} \times \text{altitude}).$
Area of triangle	$= \sqrt{s(s-a)(s-b)(s-c)},$ where $s = \frac{1}{2}(a+b+c).$
Area of parallelogram	$= \text{base} \times \text{altitude}.$
Area of trapezoid	$= \text{altitude} \times \frac{1}{2} \text{ sum of parallel sides}.$
Circumference of circle	$= \text{diameter} \times 3.1416.$
Diameter of circle	$= \begin{cases} \text{circumference} \div 3.1416. \\ \text{circumference} \times 0.3183. \end{cases}$
Area of circle	$= \begin{cases} \text{diameter squared} \times 0.7854. \\ \text{radius squared} \times 3.1416. \end{cases}$
Area of ellipse	$= \text{product of diameters} \times 0.7854.$
Area of regular polygon	$= \frac{1}{2} (\text{sum of sides} \times \text{apothem}).$
Lateral surface of cylinder	$= \text{circumference of base} \times \text{altitude}.$
Volume of cylinder	$= \text{area of base} \times \text{altitude}.$
Surface of sphere	$= \begin{cases} \text{diameter} \times \text{circumference}. \\ 4 \times 3.1416 \times \text{square of radius}. \end{cases}$
Volume of sphere	$= \begin{cases} \text{diameter cubed} \times 0.5236. \\ \frac{4}{3} \text{ of radius cubed} \times 3.1416. \end{cases}$
Surface of pyramid }	$= \frac{1}{2} (\text{circumference of base} \times \text{slant height}).$
Surface of cone }	
Volume of cone	$= \frac{1}{3} (\text{area of base} \times \text{altitude}).$

## IV.—SPECIFIC GRAVITY OF GASES \*

Name	Formula	Molecular Weight	Specific Gravity, Air = 1		Weight in Grams of 1 Liter at 0°, 760 mm. at Sea Level, lat. 45°.
			Calculated	Observed	
Acetylene . . . .	C <sub>2</sub> H <sub>2</sub>	26.016	0.8988	0.92	1.1620
Air . . . . .			1.0000		1.29330
Ammonia . . . .	NH <sub>3</sub>	17.064	0.5895	0.5971	0.7621
Argon . . . . .	A	39.9	1.379	1.379	1.7828
Arsine . . . . .	AsH <sub>3</sub>	78.024	2.696	2.695	3.485
Bromine . . . .	Br <sub>2</sub>	159.92	5.5249	5.524 (227.9°)	7.1426
Butane . . . . .	C <sub>4</sub> H <sub>10</sub>	58.08	2.0065	2.01	2.594
Carbon dioxide .	CO <sub>2</sub>	44.00	1.5201	1.52909	1.9632
Carbon monoxide .	CO	28.00	0.9673	0.96716	1.2506
Carbon oxysulphide	COS	60.06	2.0749	2.1046	2.6825
Chlorine . . . .	Cl <sub>2</sub>	70.90	2.489	2.491	3.1666
Cyanogen . . . .	C <sub>2</sub> N <sub>2</sub>	52.08	1.7993	1.8064	2.3261
Ethane . . . . .	C <sub>2</sub> H <sub>6</sub>	30.048	1.0381	1.075	1.3421
Ethylene . . . .	C <sub>2</sub> H <sub>4</sub>	28.032	0.9784	0.9852	1.2520
Fluorine . . . .	F <sub>2</sub>	38.0	1.313	1.26	1.697
Helium . . . . .	He	4	0.1382	0.1368	0.1787
Hydrobromic acid .	HBr	80.968	2.7973	2.71	3.6163
Hydrochloric acid .	HCl	36.458	1.2595	1.2692	1.6283
Hydrofluoric acid .	HF	20.008	0.691	0.7126	0.894
Hydroiodic acid .	HI	127.98	4.4172	4.3757	5.7106
Hydrogen . . . .	H <sub>2</sub>	2.016	0.06965	0.06960	0.089873
Hydrogen selenide .	H <sub>2</sub> Se	81.216	2.806	2.795	3.627
Hydrogen sulphide .	H <sub>2</sub> S	34.076	1.1773	1.1895	1.5230
Hydrogen telluride .	H <sub>2</sub> Te	129.62	4.478	4.489	5.789
Krypton . . . .	Kr	81.8	2.826	2.818	3.654
Methane . . . .	CH <sub>4</sub>	16.032	0.5539	0.5576	0.7160
Neon . . . . .	Ne	20	0.691	0.674	0.893
Nitric oxide . . .	NO	30.04	1.0378	1.0367	1.3402
Nitrous oxide . .	N <sub>2</sub> O	44.08	1.5229	1.5301	1.9688
Nitrogen . . . .	N <sub>2</sub>	28.08	0.9701	0.96737	1.2542
atmospheric . .	N <sub>2</sub> +A etc.			0.97209	1.25718
Nitrogen dioxide .	NO <sub>2</sub>	46.04	1.5906	1.60 (135°)	2.0563
Nitrogen dioxide .	N <sub>2</sub> O <sub>4</sub>	92.08	3.1812	2.65 (26.7°)	4.1126
Nitrosyl chloride .	NOCl	65.49	2.2625	2.31	2.925
Oxygen . . . . .	O <sub>2</sub>	32.00	1.1055	1.10535	1.4290
Phosphine . . . .	PH <sub>3</sub>	34.024	1.175	1.214	1.520
Propylene . . . .	C <sub>3</sub> H <sub>6</sub>	42.048	1.4527	1.498	1.8780
Silicon fluoride .	SiF <sub>4</sub>	104.4	3.607	3.60	4.663
Sulphur dioxide .	SO <sub>2</sub>	64.06	2.2131	2.2639	2.8611
Xenon . . . . .	X	128	4.422	4.422	5.717

\* Quoted from Landolt-Börnstein, *Phys.-Chem. Tabellen*, 1905, p. 222, with revisions by Olsen.

## V.—PHYSICAL CONSTANTS

Number	Name	Sym- bol	Atomic Weight O=16	Molec- ular Weight	Specific Gravity Water=1 Air=1 (A) Hydrogen= 1 (B)	Atomic Vol. At. Wt. Sp. Gr.	Specific Heat at 0° C.
1	Aluminium . .	Al	27.1		2.5834°	10.5	.2220
2	Antimony . . .	Sb	120.2		6.62	18.2	.0495
3	Argon, gas . .	A	39.9	39.9	{ 1.379 A 19.96 D		.1233
4	liquid . . . .	A	39.9		1.4046-186°	28.5	
5	Arsenic, amorph.	As	75.0	300	4.71614°	15.9	.0758 { 21°-
6	cryst. . . . .	As	75.0	300	5.72714°	13.2	.0830 { 65°
7	Barium . . . .	Ba	137.4		3.75	36.7	
8	Bismuth . . . .	Bi	208.5		9.7474	21.4	.03013
9	Boron, amorph. .	B	11.0		2.45	4.5	.3066
10	cryst. . . . .	B	11.0		2.53-2.68	4.2	
11	Bromine, gas . .	Br <sub>2</sub>	79.96	159.92	5.869160° A		.0555(83°)
12	liquid . . . .	Br <sub>2</sub>	79.96	159.92	3.18830°	25	.1071
13	Cadmium . . . .	Cd	112.4	112.4	8.64217°	13	.0548
14	Cæsium . . . .	Cs	132.9		2.366	56	.04817
15	Calcium . . . .	Ca	40.1		1.544629.2°	26	.1804
16	Carbon, amorph.	C	12.00		1.75-2.10	6.0	.241
17	graphite . . . .	C	12.00		2.10-2.585	5	.202
18	diamond . . . .	C	12.00		3.47-3.5585	3.4	.1469
19	Cerium . . . . .	Ce	140.25		7.0424	20	.04479
20	Chlorine, gas . .	Cl	35.45	70.90	2.4910° A		.1241
21	liquid . . . . .	Cl	35.45		1.44050°	24.6	.2262
22	Chromium . . . .	Cr	52.1		6.9220	7.6	.10394
23	Cobalt . [bium)	Co	59.0		8.7181°	6.8	.1030
24	Columbium (Nio-	Cb	94.0		7.0611°	13.3	
25	Copper . . . . .	Cu	63.6		8.91-8.96	7.1	.0936
26	Erbium . . . . .	Er	166		4.77	34.8	
27	Fluorine, gas . .	F	19	38	1.3115° A		
28	liquid . . . . .	F	19	38	1.14-187°	16.7	
29	Gadolinium . . .	Gd	156		1.31	119.1	
30	Gallium . . . . .	Ga	70		5.9524°	11.8	.079
31	Germanium . . .	Ge	72.5		5.4691°	13.3	.0737
32	Glucinum (Beryl-	Gl	9.1		1.8520° A	4.9	
33	Gold . . [lium)	Au	197.2		19.32	10.2	.0316
34	Helium, gas . .	He	4	4	{ 0.1368 A 1.98 D		

\* From *Van Nostrand's Chemical Annual*—Olsen.

† K = the number of grams of water which can be raised from 0° to 1° C. by the heat which passes through a cubic centimeter of the substance in

## OF THE ELEMENTS \*

Number	At. Heat Sp. Heat $\times$ At. Wt.	Electrical Conduc- tivity at 0° C.	Thermal Conduc- tivity K† at 0° C. Ag = 1.00	Linear Coefficient of Expansion		Melting Point, ° C.	Boiling Point, ° C.
					At ° C.		
1	6.02	324000	.3435	.042313	40°	657°	1470-1700°
2	5.95	27100	.0442	.041152	40°	630°	1500-1700°
3	4.92		.043894			-187.9°	-186.1°
4							
5	5.69	28600		.040559	40°		<360°
6	6.23					sublimes at	449½°
7						850°	vol. 950°
8	6.28	9260	.0177	.041346	40°	269°	1435°
9	3.37					infusible	sublimes at
10						infusible	3500°
11	4.44						
12	8.57					-7.3°	59°
13	6.16	146000	.2213	.043069	40°	321.7°	778°
14	6.41	25400		.0339482	27-100°	26.37°	670°
15	7.23	95000				780-810°	
16	2.89			.04054	40°	sublimes	3500°
17	2.22			.040786	40°	sublimes	3500°
18	1.76			.040118	40°	sublimes	3500°
19	6.28					623°	
20	4.40					-102°	-33.6°
21	8.02			.021978	0-10°		
22	5.42					1515°	
23	6.08	83200		.041236	40°	1530°	
24						1950°	
25	5.95	640600	.7198	.041678	40°	1084°	2100°
26						1065°(in air)	
27						-223°	-187°
28						-223°	-187°
29							
30	5.53					30.15°	
31	5.34					900°	vol. 1350°
32						>960°	
33	6.23	468000	.7003	.041470	0-100°	1065°	
34			.033386			<-271.3°	-267°

one second when the temperatures of the opposite sides of the cube are maintained at a difference of 1° C.

Number	Name	Sym- bol	Atomic Weight O=16	Molec- ular Weight	Specific Gravity Water=1 Air=1 (A) Hydrogen= 1 (D)	Atomic Vol. At. Wt. Sp. Gr.	Specific Heat at 0° C.
1	Hydrogen, gas . .	H	1.008	2.016	0.06949 A		3.410
2	liquid . . . .	H	1.008	2.016	0.700-252.5°	1.4	6.
3	Indium . . . .	In	115		7.121 <sup>2</sup>	16.1	.05695
4	Iodine, gas . . .	I	126.97		8.72 A		.0336 <sup>206°</sup>
5	solid . . . .	I	126.97	253.94	4.948 <sup>17°</sup>	25.7	.05412
6	Iridium, spongy .	Ir	193.0		15.86	12.2	
7	crystalline . .	Ir	193.0		22.42	8.6	.0323
8	Iron, pure . . .	Fe	55.9		7.85-7.88	7.1	.1162
9	wrought . . . .	Fe	55.9		7.86	7.1	.1130
10	steel . . . .	Fe	55.9		7.60-7.80	7.3	.1066
11	gray pig . . . .	Fe	55.9		7.03-7.13	7.9	
12	white pig . . .	Fe	55.9		7.58-7.73	7.3	.1050
13	Krypton, gas . .	Kr	81.8	81.8	{ 2.818 A 40.78 D		
14	liquid . . . .	Kr	81.8		2.155-152°	37.9	
15	Lanthanum . . .	La	138.9		6.1545	22.6	.04485
16	Lead . . . .	Pb	206.9		11.34	18.2	.0310
17	Lithium . . . .	Li	7.03		0.5936	12	.9408
18	Magnesium . . .	Mg	24.36		1.69-1.75	14.3	.2456
19	Manganese . . .	Mn	55.0		7.42	7.4	.1217
20	Mercury . . . .	Hg	200.0	200.00	13.5953 <sup>2</sup>	14.7	.03346
21	Molybdenum . .	Mo	96.0		8.6-9.01	10.9	.0659
22	Neodymium . . .	Nd	143.6		6.9563	20.6	
23	Neon . . . .	Ne	20		{ 0.674 A 9.96 D		
24	Nickel . . . .	Ni	58.7		8.6-8.93	6.7	.1084
25	Nitrogen, gas . .	N	14.04	28.08	0.96737 A		.2438
26	liquid . . . .	N	14.04		0.8042-195.5°	17.5	
27	Osmium . . . .	Os	191		22.48	8.5	.03113
28	Oxygen, gas . . .	O	16	32	1.10535 A		.2175
29	liquid . . . .	O	16	32	1.1181-182.5°	14.3	
30	Ozone . . . .	O <sub>3</sub>		48	1.658 A		
31	Palladium . . . .	Pd	106.5		11.4-11.9	9.2	.0592
32	Phosphorus, yel.	P	31	124	1.8232 <sup>20°</sup>	17.2	.202
33	red . . . .	P	31	124	2.11	14.7	.16981
34	liquid . . . .	P	31		1.76444.8°		
35	Platinum . . . .	Pt	194.8		21.4817.6°	9.2	.0323
36	Potassium . . .	K	39.15		0.875 <sup>18°</sup>	44.7	.1662
37	Praseodymium . .	Pr	140.5		6.4754	21.6	
38	Radium . . . .	Ra	225				
39	Rhodium . . . .	Rh	103.0		12.1	8.5	.05803
40	Rubidium . . . .	Rb	85.5		1.522 <sup>15°</sup>	56.3	

Number	At. Heat Sp. Heat × At. Wt.	Electrical Conduc- tivity at 0° C.	Thermal Conduc- tivity K† at 0° C. Ag = 1.00	Linear Coefficient of Expansion		Melting Point, ° C.	Boiling Point, ° C.
1	3.44		.03270		At ° C.	— 256.5°	— 252.5°
2	6.05						
3	6.56	119500		.0417	40°	115°	red heat
4	4.27						
5	6.86			.04837	—190—17	114.2°	184.35°
6							
7	6.23			.040700	40°	1950°	
8	6.50	131000	.1665	.041182	0°—100°	1804°	
9	6.32		.2070	.0411	0°—100°	1600°	
10	5.96	63000	.1300	.0411	0°—100°	1375°	
11		{ 10200—		.041061	40°	1275°	
12	5.87	{ 11300	.1490			1075°	
13						— 169°	— 151.7°
14							
15	6.23					810°	
16	3.52	50400	.0836	.042924	40°	327°	1400—1600°
17	6.62	119000				186°	> 1400°
18	5.98	230000	.3760	.042694	40°	632.6°	1100°
19	6.70					1245°	
20	6.69	10630	.0148	.03182	0°—100°	— 38.85°	357.33°
21	6.33						
22						840°	
23							{ 243° to — 233°
24	6.36	144200	.1420	.041279	40°	1484°	
25	3.42		.04524			— 210.5° (84	— 195.5°
26						[mm.]	
27	5.95	105300		.040657	40°	2500°	
28	3.48		.04563			< — 230°	— 182.5°
29							
30						decomp. 270°	— 119°
31	6.30	97900	.1683	.041176	40°	1535—1586°	
32	6.26			.03124	0°—44°	44.2°	290°
33	5.26					350° (yel.)	
34							
35	6.29	91200	.1664	.040899	40°	1710—1780°	
36	6.51	150500		.0483	0°—50°	62.5°	757.5°
37						940°	
38							
39	5.97			.040850	40°	1650—2000°	
40						38.5°	696°

† See note on p. 252.

Number	Name	Sym- bol	Atomic Weight O = 16	Molec- ular Weight	Specific Gravity Water = 1 Air = 1 (A) Hydrogen = 1 (D)	Atomic Vol. At. Wt. Sp. Gr.	Specific Heat at 0° C.
1	Ruthenium, spon.	Ru	101.7		8.6	11.8	
2	melted . . .	Ru	101.7		11.4	8.9	
3	cryst. . . .	Ru	101.7		12.268°	8.3	.0611
4	Samarium . . .	Sm	150.3		7.7-7.8	19.4	
5	Scandium . . .	Sc	44.1				
6	Selenium, amorph.	Se	79.2	633.6	4.26-4.28 <sup>250</sup>	18.5	.09533
7	monoclinic . .	Se	79.2	633.6	4.47 <sup>250</sup>	17.7	.08401
8	hexagonal . .	Se	79.2	633.6	4.8 <sup>250</sup>	16.5	
9	Silicon, amorph.	Si	28.4		2.00	14.2	
10	cryst. . . .	Si	28.4		2.49 <sup>100</sup>	11.4	.1697 <sup>220</sup>
11	Silver . . . .	Ag	107.93		10.53	10.2	.0559
12	Sodium . . . .	Na	23.05		0.9735 <sup>13.50</sup>	23.7	.2934
13	Strontium . . .	Sr	87.6		2.54	34.5	
	Sulphur,						
14	amorphous soft	S	32.06	256.48	1.9556 <sup>00</sup>	16.4	
15	“ yellow	S	32.06	256.48	2.046	15.6	
16	rhombic . . .	S <sub>α</sub>	32.06	256.48	2.05-2.07 <sup>00</sup>	15.6	.163
17	monoclinic . .	S <sub>β</sub>	32.06	256.48	1.958	16.4	
18	plastic . . .	S <sub>γ</sub>	32.06	256.48	1.92	16.7	
19	Tantalum . . .	Ta	183		12.79	143	
20	Tellurium, amorp.	Te	127.6	255.2	6.015 <sup>200</sup>	21.2	
21	cryst. . . .	Te	127.6	255.2	6.27	20.4	.0475
22	Terbium . . .	Tb	160				
23	Thallium . . .	Tl	204.1		11.85	17.2	.0326
24	Thorium, amorph.	Th	232.5		11.0017°	21.1	
25	cryst. . . .	Th	232.5		11.23	20.7	
26	Thulium . . .	Tm	171				
27	Tin, gray . . .	Sn	119.0		5.8466 <sup>150</sup>	20.3	.0545
28	rhombic . . .	Sn	119.0		6.53-6.56	18.2	.0559
29	tetragonal . .	Sn	119.0		7.2984 <sup>150</sup>	16.3	.0559
30	Titanium . . .	Ti	48.1		3.543	13.6	.1125
31	Tungsten . . .	W	184		18.77	9.8	.0336
32	Uranium . . .	U	238.5		18.685 <sup>130</sup>	12.8	.0280
33	Vanadium . . .	V	51.2		5.87 <sup>150</sup>	8.7	.1153
34	Xenon, gas . .	Xe	128		{ 4.422 A 63.5 D		
35	liquid . . . .	Xe	128		3.52-109.1°	49.1	
36	Ytterbium . . .	Yb	173.0				
37	Yttrium . . .	Yt	89.0		3.80 <sup>150</sup>	23.4	
38	Zinc . . . .	Zn	65.4		7.142 <sup>160</sup>	9.2	.09356
39	Zirconium, amorp.	Zr	90.6		4.15	21.8	
40	cryst. . . .	Zr	90.6		5.3	17.1	.0660



Number	At. Heat Sp. Heat $\times$ At. Wt.	Electrical Conduc- tivity at 0° Wt.	Thermal Conduc- tivity K† at 0° C. Ag = 1.00	Linear Coefficient of Expansion		Melting Point, ° C.	Boiling Point, ° C.
					At ° C.		
1						> 1950°	
2						2000°	
3	6.21			.040963	40°	2000°	
4							
5							
6	7.55					50°	690°
7	6.65			.043680	40°	170°-18°	690°
8						217°	690°
9							3500°
10	4.82	200-15600		.040763	40°	1200°	3500°
11	6.04	681200	1.000	.041921	40°	961.5°	2050°
12	6.76	211000	.365	.0472	0°-50°	97.6°	877.5°
13		40300				900°	
14						> 120°	444.6°
15							444.6°
16	5.23			.046413	40°	114.5°	444.6°
17						119.25°	444.6°
18							444.6°
19		60600		.0408		2250°	
20				.041675	40°	446°	1390°
21	6.07	46600		.043440	0°-20°	452°	1390°
22							
23	6.65	56800		.043021	40°	301.7°	1600-1800°
24							
25							
26							
27	6.49					stable < 20°	
28	6.65					stable > 170°	
29	6.65	76600	.1528	.042234	40°	232°	1450-1600°
30	5.41					3000°	
31	6.18					1700°	
32	6.68					800°	
33	5.90					1680°	
34						- 140°	- 109.1°
35							
36							
37							
38	6.12	186000	.2653	.042918	40°	419°	918°
39						1500°	
40	5.98						

† See note on p. 252.

## VI. — VOLUME AND WEIGHT OF WATER FROM 0° C. TO 31° C.\*

Tempera- ture	Volume of one gram in c.c.	Weight of one c.c. in grams	Tempera- ture	Volume of one gram in c.c.	Weight of one c.c. in grams
0°	1.000126	0.999874	16°	1.001025	0.998976
1	1.000070	0.999930	17	1.001193	0.998808
2	1.000030	0.999970	18	1.001373	0.998629
3	1.000007	0.999993	19	1.001564	0.998438
4	1.000000	1.000000	20	1.001768	0.998235
5	1.000008	0.999992	21	1.001981	0.998023
6	1.000031	0.999969	22	1.002204	0.997801
7	1.000069	0.999931	23	1.002438	0.997568
8	1.000122	0.999878	24	1.006781	0.997326
9	1.000188	0.999812	25	1.002935	0.997073
10	1.000269	0.999731	26	1.003199	0.996811
11	1.000363	0.999637	27	1.003472	0.996540
12	1.000470	0.999530	28	1.003788	0.996226
13	1.000590	0.999410	29	1.004045	0.995971
14	1.000722	0.999278	30	1.004346	0.995673
15	1.000867	0.999134	31	1.004656	0.995365

For the most recent results on the expansion of water, which do not differ materially from the preceding, see *Annalen d. Physik u. Chemie*, [N. F.], 60, 340 (1897).

\* *Wied. Ann.*, 47, 400 (1892).

VII.—VAPOR PRESSURE OF WATER FROM 0° C. TO 100° C.  
IN MILLIMETERS OF MERCURY.\*

Temp.	Pressure	Temp.	Pressure	Temp.	Pressure	Temp.	Pressure
0	4.569	25	23.517	50	91.98	75	288.76
1	4.909	26	24.956	51	96.66	76	301.09
2	5.272	27	26.471	52	101.55	77	313.85
3	5.658	28	28.065	53	106.65	78	327.05
4	6.069	29	29.744	54	111.97	79	340.73
5	6.507	30	31.51	55	117.52	80	354.87
6	6.972	31	33.37	56	123.29	81	369.51
7	7.466	32	35.32	57	129.31	82	384.64
8	7.991	33	37.37	58	135.58	83	400.29
9	8.548	34	39.52	59	142.10	84	416.47
10	9.140	35	41.78	60	148.88	85	433.19
11	9.767	36	44.16	61	155.95	86	450.47
12	10.432	37	46.65	62	163.29	87	468.32
13	11.137	38	49.26	63	170.02	88	486.76
14	11.884	39	52.00	64	178.86	89	505.81
15	12.674	40	54.87	65	187.10	90	525.47
16	13.510	41	57.87	66	195.67	91	545.77
17	14.395	42	61.02	67	204.56	92	566.71
18	15.330	43	64.31	68	213.79	93	588.83
19	16.319	44	67.76	69	223.37	94	610.64
20	17.363	45	71.36	70	233.31	95	633.66
21	18.466	46	75.13	71	243.62	96	657.40
22	19.630	47	79.07	72	254.30	97	681.88
23	20.858	48	83.19	73	265.38	98	707.13
24	22.152	49	87.49	74	276.87	99	733.16

\* Taken from Ostwald's *Manual of Physico-Chemical Measurements*.

## VIII. — TABLE OF ELECTRO-CHEMICAL EQUIVALENTS

Table of Electro-chemical Equivalents based on the definition of the ampere and the atomic weights, oxygen being 16

Element	Atomic Weight	Valency	Chemical Equivalent	Electro-chemical Equivalent Grams per coulomb	Coulombs per gram	Grams per ampere-hour	Ampere-hours per pound
<i>Electropositive</i>							
Aluminum . . . . .	27.11	3.	9.037	.00009362	10680.	.3370	1346.
Antimony . . . . .	120.43	3.	40.14	.0004159	2405.	1.497	303.0
Bismuth . . . . .	208.11	3.	69.37	.0007186	1392.	2.587	175.3
Cadmium . . . . .	112.38	2.	56.19	.0005821	1718.	2.096	216.4
Cobalt . . . . .	58.99	2.	29.5	.0003056	3272.	1.100	412.2
Copper (cuprous) . . . . .	63.6	1.	63.6	.0006589	1518.	2.372	191.2
Copper (cupric) . . . . .	63.6	2.	31.8	.0003295	3036.	1.186	382.4
Gold . . . . .	197.23	3.	65.78	.0006815	1467.	2.453	184.7
Hydrogen . . . . .	1.008	1.	1.008	.00001044	95785.	.03758	12070.
Iron (ferrous) . . . . .	56.02	2.	28.01	.0002902	3446.	1.045	434.0
Iron (ferric) . . . . .	56.02	3.	18.67	.0001934	5171.	.6962	651.5
Lead . . . . .	206.92	2.	103.5	.001072	932.8	3.859	117.5
Magnesium . . . . .	24.28	2.	12.14	.0001258	7949.	.4528	1001.
Manganese . . . . .	54.99	2.	27.50	.0002849	3510.	1.026	442.1
Mercury (mercurous) . . . . .	200.	1.	200.	.002072	482.6	7.459	60.81
Mercury (mercuric) . . . . .	200.	2.	100.	.001036	965.3	3.730	121.6
Nickel . . . . .	58.69	2.	29.35	.0003041	3288.	1.095	414.2
Platinum . . . . .	194.89	4.	48.72	.0005047	1981.	1.817	249.6
Potassium . . . . .	39.11	1.	39.11	.0004052	2468.	1.459	310.9
Silver . . . . .	107.92	1.	107.92	.001118	894.5	4.025	112.7
Sodium . . . . .	23.05	1.	23.05	.0002388	4188.	.8597	527.6
Tin (stannous) . . . . .	119.05	2.	59.52	.0006166	1622.	2.220	204.3
Tin (stannic) . . . . .	119.05	4.	29.76	.0003083	3243.	1.110	408.6
Zinc . . . . .	65.41	2.	32.70	.0003388	2952.	1.220	371.8
<i>Electronegative</i>							
Bromine . . . . .	79.95	1.	79.95	.0008283	1207.	2.982	152.1
Chlorine . . . . .	35.45	1.	35.45	.0003673	2723.	1.322	343.1
Iodine . . . . .	126.85	1.	126.85	.001314	761.0	4.730	95.90
Nitrogen . . . . .	14.04	3.	4.68	.00004848	20627.	.1745	2599.
Oxygen . . . . .	16.	2.	8.	.00008288	12066.	.2984	1520.

# IX.—TABLE SHOWING THE RELATIONS BETWEEN UNITS OF ELECTRICITY, HEAT, AND POWER

1 ampere = 1 volt ÷ 1 ohm.  
 " = 1 coulomb per second.

1 ampere hour = 1 coulomb per second kept up for one hour.

1 ampere hour = 3600 coulombs.

1 volt = 1 ampere × 1 ohm.

1 ohm = 1 volt ÷ 1 ampere.

1 joule = 1 volt × 1 coulomb.

" = .2381 calorie.

" = .73732 foot-pound.

" = .10194 kilogram-meter.

1 calorie = 4.2 joules.

" = 3.0968 foot-pounds.

" = .42815 kilogram-meter.

1 foot-pound = 1.3563 joules.

" = .32292 calorie.

" = .13825 kilogram-meter.

1 kilogram-meter = 9.81 joules.

" = 2.3362 calories.

" = 7.233 foot-pounds.

1 watt-hour = 1 watt kept up for one hour.

1 watt-hour = 1 joule per second kept up for one hour.

1 watt-hour = 3600 joules.

" = 857.16 calories.

" = 2654.4 foot-pounds.

" = 366.98 kilogram-meters.

1 watt = 1 joule per second.

" = .2381 calorie per second.

" = .73732 foot-pound per second.

1 watt = .10194 kilogram-meter per second.

1 watt = .0013406 horse-power.

" = .001 kilowatt.

1 horse-power = 745.94 watts.

" = 177.6 calories per second.

1 horse-power = 10656 calories per minute.

1 horse-power = 550 foot-pounds per second.

1 horse-power = 33000 foot-pounds per minute.

1 horse-power = 76.04 kilogram-meters per second.

1 horse-power = 4562.4 kilogram-meters per minute.

1 horse-power = .74594 kilowatt.

1 kilowatt = 1000 watts.

" = 1000 joules per second.

" = 238.1 calories per second.

1 kilowatt = 14286 calories per minute.

1 kilowatt = 737.32 foot-pounds per second.

1 kilowatt = 44239 foot-pounds per minute.

1 kilowatt = 101.94 kilogram-meters per second.

1 kilowatt = 6116.4 kilogram-meters per minute.

1 kilowatt = 1.3406 horse-power.

## X.—HEATS OF COMBINATION

Heats of Combination in Calories, for Equivalent Weights in Grams,  
of Chlorides, Bromides, Iodides, Sulphate, and Nitrates \*

Element	Valence	Chloride	Bromide	Iodide	Sulphate	Nitrate
Aluminium . . .	3	53660	39900	23463	25315	
Antimony . . .	3	30463				
Bismuth . . .	3	30210				
Cadmium . . .	2	46620	37600	24215	44940	43000
Cobalt . . .	2	38240			44350	42270
Copper . . .	1	32875	24985	16260		
Copper . . .	2				27980	26205
Gold . . .	3	7607	2950			
Hydrogen . . .	1	39315	28380	13170	39170	33830
Iron . . .	2	41025			46600	44835
Lead . . .	2	41385	32225	19900		34035
Magnesium . . .	2	75505			90090	88240
Manganese . . .	2	55995			60625	58860
Mercury . . .	2	31580	17155			18535
Nickel . . .	2	37265			43475	41710
Silver . . .	1	29380	22700	13800	10195	8390
Tin . . .	2	40395				
Zinc . . .	2	48605	37965	24615	53045	51255

\* These values are taken from Thomsen's *Thermo-chemische Untersuchungen*. The sulphates, nitrates, and hydrogen compounds are for aqueous solutions. The chlorides, bromides, and iodides are anhydrous.

## XI.—SPECIFIC RESISTANCE OF VARIOUS SUBSTANCES

Substance	Temperature	Specific Gravity	$\rho$ in Ohms	% Solution	Observer
Silver (annealed) . . . . .	0° C.	10.6	.000001500		Matthiesen
Silver (hard drawn) . . . . .	"	10.6	.000001530		"
Copper (annealed) . . . . .	"	8.9	.000001594		"
Copper (hard drawn) . . . . .	"	8.9	.000001629		"
Gold (annealed) . . . . .	"	19.3	.000002052		"
Gold (hard drawn) . . . . .	"	19.3	.000002089		"
Aluminium (annealed) . . . . .	"	2.6	.000002908		"
Platinum (annealed) . . . . .	"	21.2	.000009030		"
Iron (annealed) . . . . .	"	8.1	.000009687		"
Tin (pressed) . . . . .	"	7.3	.00001317		"
Zinc (pressed) . . . . .	"	7.1	.000005598		"
Lead (pressed) . . . . .	"	11.4	.00001957		"
Nickel (pressed) . . . . .	"	8.5	.00001242		"
German silver . . . . .	"		about .0000209		"
Graphite . . . . .	"	2.3	.0024 to .042		Eyertt
Retort carbon . . . . .	"	1.9	.07		"
Mercury . . . . .	"	13.6	.000094073*		
Nitric acid in water . . . . .	18° C.	1.185	1.28 †	29.7	Kohlrausch
Hydrochloric acid in water . . . . .	"	1.092	1.31 †	18.3	"
Sulphuric acid in water . . . . .	"	1.224	1.36 †	30.4	"
Phosphoric acid in water . . . . .	"	1.307	4.79 †	46.8	"
Tartaric acid in water . . . . .	"	1.107	9.97 †	22.4	"
Acetic acid in water . . . . .	"	1.022	61.9 †	16.6	"
Ammonium chloride in water . . . . .	10° C.		2.5 †		} Kohlrausch and Nippoldt
Sodium chloride in water . . . . .	"		4.7 †		
Sodium sulphate in water . . . . .	"		11.3 †		
Zinc sulphate in water . . . . .	"	1.270	28.5 †		} Ewing and Macgregor.
Zinc sulphate in water . . . . .	"	1.422	33.7 †		
Copper sulphate in water . . . . .	"	1.205	29.3 †		
Potassium sulphate in water . . . . .	"		16.6 †		
Potassium bichromate in water . . . . .	"		29.6 †		

Further data on the conductivity of the solutions can be found in *Physikalisch-Chemische Tabellen*, Landolt and Börnstein, pp. 103, 106.

Kohlrausch and Nippoldt, *Pogg. Ann.*, 138, p. 379 (1869).

Grottrian *Pogg. Ann.*, 151, p. 378 (1874).

Kohlrausch and Grottrian, *Pogg. Ann.*, 159, p. 233 (1876); and *Wied. Ann.*, 6, p. 145 (1879).

\* From the definition of the ohm.

† Solution of minimum resistance.

‡ Saturated solution.

## XII.—DENSITIES OF VARIOUS SUBSTANCES

The following table gives the weight in grams of 1 cc. of the substance. These densities are but approximate.

Acetic acid . . . . .	1.064	Clay . . . . .	1.920
Agate . . . . .	2.615	Coal, anthracite . . . . .	1.26 to 1.800
Alcohol, absolute . . . . .	0.796	Coal, bituminous . . . . .	1.27 to 1.423
Alcohol, methyl . . . . .	0.796	Cobalt . . . . .	8.800
Alum . . . . .	1.724	Concrete, ordinary . . . . .	1.900
Aluminium . . . . .	2.670	Concrete, in cement . . . . .	2.200
Amber . . . . .	1.078	Cork . . . . .	0.240
Antimony, cast . . . . .	6.720	Copper, cast . . . . .	8.830
Apple-tree wood . . . . .	0.790	Copper, sheet . . . . .	8.878
Arsenic . . . . .	8.310	Deal, Norway . . . . .	0.689
Ash, dry . . . . .	0.690	Diamond . . . . .	3.530
Ash, green . . . . .	0.760	Earth . . . . .	1.52 to 2.000
Asphalt . . . . .	2.500	Ebony . . . . .	1.187
Basalt . . . . .	2.950	Elder . . . . .	0.690
Beech, dry . . . . .	0.690 to 0.800	Elm . . . . .	0.579
Beeswax . . . . .	0.964	Elm, Canadian . . . . .	0.725
Bell-metal . . . . .	8.050	Emerald . . . . .	2.770
Benzine . . . . .	0.72 to 0.740	Emery . . . . .	3.900
Benzole . . . . .	0.884	Ether . . . . .	0.720
Birch . . . . .	0.690	Feldspar . . . . .	2.600
Bismuth, cast . . . . .	9.822	Fir, spruce . . . . .	0.512
Blood . . . . .	1.060	Fluorspar . . . . .	3.200
Boxwood . . . . .	1.280	Galena . . . . .	7.580
Brass, cast . . . . .	8.400	German silver . . . . .	8.432
Brass, sheet . . . . .	8.440	Glass, flint . . . . .	3.0 to 3.600
Brick . . . . .	1.6 to 2.000	Glass, crown . . . . .	2.520
Bromine . . . . .	3.187	Glass, plate . . . . .	2.760
Butter . . . . .	0.942	Glycerine . . . . .	1.260
Calcium chloride . . . . .	2.230	Gold . . . . .	19.360
Camphor . . . . .	0.988	Gypsum, crys. . . . .	2.310
Carbon disulphide . . . . .	1.272	Granite . . . . .	2.650
Carbon dioxide, liquid . . . . .	0.947	Graphite . . . . .	2.500
Cedar, American . . . . .	0.554	Gun-metal . . . . .	8.561
Chalk . . . . .	1.8 to 2.800	Gutta-percha . . . . .	0.966
Cherry-tree . . . . .	0.710	Heavy-spar . . . . .	4.430
Chestnut . . . . .	0.606	Honey . . . . .	1.450
Chloroform . . . . .	1.500	Human body . . . . .	0.890



XII. — DENSITIES OF VARIOUS SUBSTANCES — *Continued*

Hydrochloric acid, aq. sol.	1.222	Phosphorus . . . . .	1.830
Ice . . . . .	0.917	Pear-tree . . . . .	0.660
Iceland spar . . . . .	2.723	Pine, red, dry . . . . .	0.590
Iron, bar . . . . .	7.788	Pine, white, dry . . . . .	0.554
Iron, cast . . . . .	7.230	Pine, yellow, dry . . . . .	0.461
Iron, wrought . . . . .	7.780	Pine, pitch . . . . .	0.660
India-rubber . . . . .	0.930	Pitch . . . . .	1.150
Iodine . . . . .	4.950	Platinum wire . . . . .	21.531
Iron pyrites . . . . .	5.000	Poplar, common . . . . .	0.389
Ivory . . . . .	1.820	Porcelain, china . . . . .	2.380
Lard . . . . .	0.947	Potassium . . . . .	0.865
Lead, cast . . . . .	11.360	Quartz . . . . .	2.650
Lead, sheet . . . . .	11.400	Rock salt . . . . .	2.257
Lignum vitæ . . . . .	1.333	Salt peter . . . . .	2.100
Limè, quick . . . . .	0.843	Sand, quartz . . . . .	2.750
Limestone . . . . .	3.180	Sand, river . . . . .	1.880
Logwood . . . . .	0.913	Sand, fine . . . . .	1.520
Magnesium . . . . .	1.750	Sand, coarse . . . . .	1.510
Mahogany . . . . .	0.56 to 0.852	Silver, cast . . . . .	10.424 to 10.511
Maple . . . . .	0.755	Slate . . . . .	2.880
Marble . . . . .	2.720	Sodium . . . . .	0.970
Mercury . . . . .	13.596	Steel, unhammered . . . . .	7.816
Milk . . . . .	1.032	Sugar, cane . . . . .	1.593
Molasses . . . . .	1.426	Sulphur, native . . . . .	2.033
Mortar, average . . . . .	1.700	Sulphuric acid . . . . .	1.840
Naphtha . . . . .	0.848	Tallow . . . . .	0.940
Nitric acid . . . . .	1.38 to 1.559	Tar . . . . .	1.015
Oak, American red . . . . .	0.850	Tin, cast . . . . .	7.290
Oak, American white . . . . .	0.779	Tourmaline, green . . . . .	3.150
Oak, live, seasoned . . . . .	1.068	Vinegar . . . . .	1.026
Oak, live, green . . . . .	1.260	Water, at 100° C. . . . .	0.958
Oil, castor . . . . .	0.970	Walnut . . . . .	0.680
Oil, linseed . . . . .	0.940	Water, sea . . . . .	1.027
Oil, olive . . . . .	0.915	Wax, white . . . . .	0.970
Oil, turpentine . . . . .	0.870	White metal, Babbitt . . . . .	7.310
Oil, whale . . . . .	0.923	Willow . . . . .	0.585
Paraffin . . . . .	0.824 to 0.940	Zinc, cast . . . . .	7.000
Petroleum . . . . .	0.836		

## XIII. — TABLE OF SOLUBILITIES \*

*Showing the classes to which the compounds of the commonly occurring elements belong in respect to their solubility in water, hydrochloric acid, nitric acid, or aqua regia.*

*Preliminary Remarks*

For the sake of brevity, the classes to which the compounds belong are expressed by letters, as follows:

W or w, soluble in water.

A or a, insoluble in water, but soluble in hydrochloric acid, nitric acid, or in *aqua regia*.

I or i, insoluble in water, hydrochloric acid, or nitric acid.

Further, substances standing on the border lines are indicated as follows:

W-A or w-a, difficultly soluble in water, but soluble in hydrochloric acid or nitric acid.

W-I or w-i, difficultly soluble in water, the solubility not being greatly increased by the addition of acids.

A-I or a-i, insoluble in water, difficultly soluble in acids.

If the behavior of a compound to hydrochloric and nitric acids is essentially different, this is stated in the notes.

Capital letters indicate common substances used in the arts and in medicine, while the small letters are used for those less commonly occurring. The salts are generally considered as normal, but basic and acid salts, as well as double salts, in case they are important in medicine or in the arts, are referred to in the notes. The small numbers in the table refer to notes on the following pages.

*Notes to Table of Solubilities*

1. Potassium dichromate, W.
2. Potassium borotartrate, W.
3. Hydrogen potassium oxalate, W.
4. Hydrogen potassium carbonate, W.

\* Taken from Wells' translation of the 16th German edition of Fresenius' *Qualitative Analysis*.

SOLUBILITY TABLE

	Potassium	Sodium	Ammonium	Barium	Strontium	Calcium	Magnesium	Aluminium
Oxide . . . .	W	W	W	W	w	W-A	A	A
Chromate . . .	W <sub>1</sub>	w	w	a	w-a	w-a	w	
Sulphate . . .	W <sub>13-15</sub>	W	W <sub>14-20-30</sub>	I	I	W-I	W	W <sub>13-14</sub>
Phosphate . .	w	W <sub>8</sub>	W <sub>8-12</sub>	a	a	A <sub>11</sub>	a	a
Borate . . . .	w <sub>2</sub>	w <sub>9</sub>	w	a	a	a	w-a	a
Oxalate . . . .	W <sub>3</sub>	W	W	a	a	A	a	a
Fluoride . . .	w	w	W	w-a	w-a	A-I	a-i	w
Carbonate . . .	W <sub>4</sub>	W <sub>10</sub>	W	A	A	A	A	
Silicate . . . .	W	W		a	a	a	a	a-i
Chloride . . . .	W <sub>37</sub>	W <sub>35</sub>	W <sub>21-38</sub>	W	W	W	W	w
Bromide . . . .	W	W	w	w	w	w	w	w
Iodide . . . .	W	w	W	w	w	w	w	w
Cyanide . . . .	W	w	w	w-a	w	w	w	
Ferrocyanide .	W	w	w	w-a	w	w	w	
Ferricyanide .	W	w	w			w	w	
Thiocyanate . .	W	w	W	w	w	w	w	
Sulphide . . . .	W	W	W	W	w	W-A <sub>45</sub>	a	a
Nitrate . . . .	W	W	W	W	W	w	w	w
Chlorate . . . .	W	w	w	w	W	w	w	w
Tartrate . . . .	W <sub>5-6-7-22-46</sub>	W <sub>7</sub>	w <sub>6</sub>	a	a	A	w-a	w
Citrate . . . .	w	w	w	a	a	w-a	w	w
Malate . . . .	w	w	w	w & a	w	w-a <sub>47</sub>	w	w
Succinate . . .	w	w	w	w-a	w-a	w-a	w	w-a
Benzoate . . . .	w	w	w	w		w	w	
Salicylate . . .	w	W	W	w-a	w-a	w-a	w	
Acetate . . . .	W	W	W	W	w	W	w	W
Formate . . . .	w	w	w	w	w	w	w	w
Arsenite . . . .	W	w	w	a	a	a	a	
Arsenate . . . .	W	W	w	a	a	a	a	a

5. Hydrogen potassium tartrate, W.
6. Ammonium potassium tartrate, W.
7. Sodium potassium tartrate, W.
8. Ammonium sodium phosphate, W.
9. Acid sodium borate, W.
10. Hydrogen sodium carbonate, W.
11. Tricalcium phosphate, A.
12. Ammonium magnesium phosphate, A.
13. Potassium aluminium sulphate, W.

SOLUBILITY TABLE — *Continued*

	Chromium	Zinc	Manganese	Nickel	Cobalt	Ferrous	Ferric	Silver	Lead	Mercurous
Oxide . . . . .	A & I	A	a <sub>17</sub>	A	A	a	A	a	A <sub>24</sub>	A
Chromate . . . . .	a	w	w	a	a	w	w	a	A-I	a
Sulphate . . . . .	W & I <sub>15</sub>	W	W	W	W	W <sub>20</sub>	W	W-A	A-I	w-a
Phosphate . . . . .	a	a	a	a	a	A	A	a	a	a
Borate . . . . .	a	a	a	a	a	a	a	a	a	a
Oxalate . . . . .	w-a	a	w-a	a	a	a	s	a	a	a
Fluoride . . . . .	w	w-a	a	w-a	w-a	w-a	w	w	a	a
Carbonate . . . . .	A	A	A	A	A	A	A	a	A	a
Silicate . . . . .	a	a	a	a	a	a	a	a	a	a
Chloride . . . . .	W & I	W	W	W	W	W	W <sub>21</sub>	I	W-I	A-I
Bromide . . . . .	w & i	w	w	w	w	w	w	i	w-i	a-i
Iodide . . . . .	w	w	w	w	w	W	w	i	W-A	A
Cyanide . . . . .	a	A	a	a-i	a-i	a-i	I	I	a	a
Ferrocyanide . . . . .		A-I	a	i	i	i	I	i	a	a
Ferrieyanide . . . . .		a	i	i	i	I	w	i	w-a	a
Thiocyanate . . . . .	w	w	w	w	w	w	w	i	a	A
Sulphide . . . . .	a-i	A <sub>16</sub>	A	a <sub>18</sub>	a <sub>19</sub>	A	a	a <sub>23</sub>	A	A
Nitrate . . . . .	W	w	w	w	W	w	w	W	W	W <sub>26</sub>
Chlorate . . . . .	w	w	w	w	w	w	w	w	w	w
Tartrate . . . . .	w	a	w-a	a	w	w-a	W <sub>22</sub>	a	a	w-a
Citrate . . . . .	w	w-a	a	w	w	w	W	a	a	a
Malate . . . . .		w	w				W	w-a	w-a	a
Succinate . . . . .		w-a	w	w	w-a	w-a	a	a	a	a
Benzoate . . . . .			w			w	a	w-a	a	a
Salicylate . . . . .								w-a	w-a	
Acetate . . . . .	w	W	w	w	w	w	W	w	W <sub>25</sub>	w-a
Formate . . . . .	w	w	w	w	w	w	W	w	w-a	w
Arsenite . . . . .			a	a	a	a	a	a	a	a
Arsenate . . . . .	a	a	a	a	a	a	a	a	a	a

14. Ammonium aluminium sulphate, W.

15. Potassium chromium sulphate, W.

16. Zinc sulphide, as a sphalerite, soluble in nitric acid, with separation of sulphur; in hydrochloric acid only upon heating.

17. Manganese dioxide, easily soluble in hydrochloric acid; insoluble in nitric acid.

18. Nickel sulphide is rather easily decomposed by nitric acid; very difficultly by hydrochloric acid.

SOLUBILITY TABLE — *Concluded*

	Mercuric	Cupric	Bismuth	Cadmium	Gold	Platinum	Stannous	Stannic	Antimonious
Oxide . . . . .	A	A	a	a		a	a	a & i	A <sub>42</sub>
Chromate . . . . .	w-a	w	a	a			a		a
Sulphate . . . . .	w <sub>27</sub>	W <sub>30</sub>	w	W		w	w		a
Phosphate . . . . .	a	a	a	a			a	a	w-a
Borate . . . . .		a	a	w-a			a		
Oxalate . . . . .	a	a	a	a		w	a	w	a
Fluoride . . . . .	w-a	a	w	w-a			w	w	w
Carbonate . . . . .	a	A	a	a					
Silicate . . . . .		a		a					
Chloride . . . . .	W <sub>28</sub>	W	W-A <sub>33</sub>	W	W <sub>35</sub>	W <sub>37-38</sub>	W	W <sub>40</sub>	W-A <sub>43</sub>
Bromide . . . . .	w	w	w-a	W	w	w			w-a
Iodide . . . . .	A	w	a	W	a	i	w	w	w-a
Cyanide . . . . .	W	a		a	W	w			
Ferrocyanide . . . . .		i		w-a			i	i	
Ferricyanide . . . . .							i		
Thiocyanate . . . . .	w	a				a		w	
Sulphide . . . . .	A <sub>29</sub>	a <sub>31</sub>	a	A	a <sub>36</sub>	a <sub>39</sub>	a <sub>41</sub>	a <sub>41</sub>	A <sub>44-45</sub>
Nitrate . . . . .	W	W	W <sub>34</sub>	w		w			
Chlorate . . . . .	w	w	w	w			w		
Tartrate . . . . .	a	w	a	w-a			a		a <sub>46</sub>
Citrate . . . . .	w-a	w		a					
Malate . . . . .	w-a	w					w	w	
Succinate . . . . .	w-a	w		w				a	
Benzoate . . . . .	w-a	a		w					
Salicylate . . . . .		w							
Acetate . . . . .	w	W <sub>32</sub>	w	w			w	w	
Formate . . . . .	w	w	w	w			w		
Arsenite . . . . .	a	A							a
Arsenate . . . . .	a	a	a					a	a

19. Cobalt sulphide, like nickel sulphide.

20. Ammonium ferrous sulphate, W.

21. Ammonium ferric chloride, W.

22. Potassium ferric tartrate, W.

23. Silver sulphide, only soluble in nitric acid.

24. Minium is converted by hydrochloric acid into lead chloride; by nitric acid into soluble lead nitrate and brown lead peroxide which is insoluble in nitric acid.

25. Tribasic lead acetate, W.

26. *Mercurius solubilis Hahnemanni*, A.
27. Basic mercuric sulphate, A.
28. Mercuric amido-chloride, A.
29. Mercuric sulphide, not soluble in hydrochloric acid, nor in nitric acid, but soluble in *aqua regia* upon heating.
30. Ammonium cupric sulphate, W.
31. Copper sulphide is decomposed with difficulty by hydrochloric acid, but easily by nitric acid.
32. Basic cupric acetate, partially soluble in water, and completely in acids.
33. Basic bismuth chloride, A.
34. Basic bismuth nitrate, A.
35. Sodium auric chloride, W.
36. Gold sulphide is not dissolved by hydrochloric acid, nor by nitric acid, but it is dissolved by hot *aqua regia*.
37. Potassium chlorplatinat, W-I.
38. Ammonium chlorplatinat, W-I.
39. Platinum sulphide is not attacked by hydrochloric acid, is but slightly attacked by boiling nitric acid (if it has been precipitated hot), but is dissolved by hot *aqua regia*.
40. Ammonium stannic chloride, W.
41. Stannous sulphide and stannic sulphide are decomposed and dissolved by hot hydrochloric acid, and are converted by nitric acid into oxide, which is insoluble in an excess of nitric acid. Sublimed stannic sulphide is dissolved only by hot *aqua regia*.
42. Antimonious oxide, soluble in hydrochloric acid, not in nitric acid
43. Basic antimonious chloride, A.
44. Antimony sulphide is completely dissolved by hydrochloric acid, especially upon heating; it is decomposed by nitric acid, but dissolved only to a slight degree.
45. Calcium antimony sulphide, W-A.
46. Potassium antimony tartrate, W.
47. Hydrogen calcium malate, W.

## XIV.—SOLUTIONS \*

*Acids*

*Conc. HCl*, sp. gr. 1.2, 39 % HCl by weight.

*Dil. HCl*, 3 N, sp. gr. 1.05, 10 % HCl by weight.

*Conc. HNO<sub>3</sub>*, sp. gr. 1.42, 70 % HNO<sub>3</sub> by weight.

*Dil. HNO<sub>3</sub>*, 3 N, sp. gr. 1.10, 10 % HNO<sub>3</sub> by weight.

*Conc. H<sub>2</sub>SO<sub>4</sub>*, sp. gr. 1.84, 98 % H<sub>2</sub>SO<sub>4</sub>.

*Dil. H<sub>2</sub>SO<sub>4</sub>*, 3 N, sp. gr. 1.09, 13 % H<sub>2</sub>SO<sub>4</sub>.

*Conc. HF*, 40 %.

*Acetic Acid*, 2 N, 120 g. of glacial acetic acid in 1 liter.

*Tartaric Acid*, 2 N, 150 g. in 1 liter.

*Aqua Regia*, 1 part of conc. HNO<sub>3</sub> to 3 parts conc. HCl; to be prepared only when needed.

H<sub>2</sub>S gas is prepared by the action of HCl (1:1) on FeS; the gas should be washed by passing it through water before using.

*Bases*

*Conc. Ammonia*, sp. gr. 0.90, 28 % NH<sub>3</sub>.

*Dil. Ammonia*, sp. gr. 0.96, 10 % NH<sub>3</sub>.

*Sodium hydroxide*, NaOH, 4 N.

As the material used for qualitative purposes contains about 10 % of water, the amount needed for a 4 N solution will be  $4 \times 40 \times \frac{10}{9} = 177.7$  g. in 1 liter.

*Potassium hydroxide*, KOH, 4 N.

The grade used for analytical purposes contains about 20 % water; hence the quantity needed for a 4 N solution will be  $4 \times 56 \times \frac{5}{4} = 280$  g. in 1 liter.

*Barium hydroxide*, Ba(OH)<sub>2</sub>, saturated solution.

*Calcium hydroxide*, Ca(OH)<sub>2</sub>, saturated solution.

\* Taken from Baskerville and Curtman's *Qualitative Analysis*, New York, 1910.

*Salts*

*Ammonium acetate*,  $\text{NH}_4\text{C}_2\text{H}_3\text{O}_2$ . Add 1000 cc. of ammonium hydroxide (sp. gr. 0.90), slowly and with constant stirring, to 1250 cc. of glacial acetic acid.

*Ammonium carbonate*,  $(\text{NH}_4)_2\text{CO}_3\text{SO}_4$  free. Dissolve, without heating, 192 g. of the powdered salt in a mixture of 80 cc. of  $\text{NH}_4\text{OH}$  (sp. gr. 0.90) and 500 cc. of water. When solution is complete, dilute to 1 liter. The strength is approximately 4 N.

*Ammonium chloride*,  $\text{NH}_4\text{Cl}$ , 4 N. 214 g. in 1 liter.

*Ammonium molybdate solution*. To a mixture of 271 cc. of cold distilled water and 144 cc. of  $\text{NH}_4\text{OH}$  (sp. gr. 0.90), add 100 g.  $\text{MoO}_3$  and stir till solution is complete; slowly add this solution with constant stirring to a mixture of 489 cc.  $\text{HNO}_3$  (sp. gr. 1.42) and 1148 cc. of water. Allow the mixture to stand for 24 hours and then decant the clear liquid into a bottle.

*Ammonium oxalate*,  $(\text{NH}_4)_2\text{C}_2\text{O}_4 \cdot \text{H}_2\text{O}$ . 35.54 g. in 1 liter.

*Ammonium sulphide* (colorless),  $(\text{NH}_4)_2\text{S}$ . Saturate 3 parts of  $\text{NH}_4\text{OH}$  with  $\text{H}_2\text{S}$ , add 2 parts of ammonium hydroxide, and dilute with an equal volume of water.

*Ammonium sulphide* (yellow),  $(\text{NH}_4)_2\text{S}_x$ . Digest the colorless undiluted  $(\text{NH}_4)_2\text{S}$  with flowers of sulphur in the proportion of 1 g. to the liter and then dilute with an equal volume of water.

*Ammonium sulphate*,  $(\text{NH}_4)_2\text{SO}_4$ , N. 100 g. in 1 liter.

*Barium chloride*,  $\text{BaCl}_2 \cdot 2 \text{H}_2\text{O}$ , N. 122.17 g. in 1 liter.

*Bromine water*, saturated solution.

*Calcium chloride*,  $\text{CaCl}_2$ , anhydrous, N. 55.6 g. in 1 liter.

*Calcium sulphate*,  $\text{CaSO}_4 \cdot 2 \text{H}_2\text{O}$ , saturated solution.

*Chlorine water*, saturated solution.

*Cobalt nitrate*,  $\text{Co}(\text{NO}_3)_2 \cdot 6 \text{H}_2\text{O}$ , for confirmatory tests for Al and Zn. 0.5 g. in 1 liter.



*Ferric alum*,  $\text{Fe}_2(\text{SO}_4)_3 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 24 \text{ H}_2\text{O}$ , saturated solution.

*Ferric chloride*,  $\text{FeCl}_3 \cdot 6 \text{ H}_2\text{O}$ ,\* 2 N. 180 g. in 1 liter.

*Ferrous sulphate*,  $\text{FeSO}_4 \cdot 7 \text{ H}_2\text{O}$ . To be prepared in small amounts as needed.

*Hydrochlorplatinic acid*,  $\text{H}_2\text{PtCl}_6 \cdot 6 \text{ H}_2\text{O}$ . 10 % solution.

*Hydrogen dioxide*, 3 %.

*Lead acetate*,  $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 3 \text{ H}_2\text{O}$ ,† N. 189.5 g. in 1 liter.

*Magnesia mixture*. Dissolve 110 g. of  $\text{MgCl}_2 \cdot 6 \text{ H}_2\text{O}$  and 280 g. of  $\text{NH}_4\text{Cl}$  in a liter of distilled water; when solution is complete, add 261 cc. of ammonium hydroxide (sp. gr. 0.90), then add enough water to make the volume 2 liters.

*Mercuric chloride*,  $\text{HgCl}_2$ . Saturated solution.

*Potassium acetate*,  $\text{KC}_2\text{H}_3\text{O}_2$ . Saturated solution.

*Potassium chromate*,  $\text{K}_2\text{CrO}_4$ , N. 97.3 g. in 1 liter.

*Potassium cyanide*,  $\text{KCN}$ , N. 65.2 g. in 1 liter.

*Potassium dichromate*,  $\text{K}_2\text{Cr}_2\text{O}_7$ , N. 73.8 g. in 1 liter.

*Potassium ferrocyanide*,  $\text{K}_4\text{Fe}(\text{CN})_6$ , N. 105.7 g. in 1 liter.

*Potassium iodide*,  $\text{KI}$ ,  $\frac{\text{N}}{2}$ . 83.1 g. in 1 liter.

*Potassium nitrate*,  $\text{KNO}_3$ . 500 g. in 1 liter.

*Potassium permanganate*,  $\text{KMnO}_4$ , N. 79.1 g. in 1 liter.

*Potassium thiocyanate*,  $\text{KCNS}$ , N. 97.2 g. in 1 liter.

*Silver nitrate*,  $\text{AgNO}_3$ ,  $\frac{\text{N}}{4}$ . 42.5 g. in 1 liter.

*Silver sulphate*,  $\text{Ag SO}_4$ . Saturated solution.

*Sodium acetate*,  $\text{NaC}_2\text{H}_3\text{O}_2$ , 4 N. 328 g. in 1 liter.

*Sodium carbonate*,  $\text{Na}_2\text{CO}_3$  (dry). Saturated solution.

*Sodium cobaltic nitrite*,  $\text{Na}_3\text{Co}(\text{NO}_2)_6$ . Dissolve 100 g.  $\text{NaNO}_2$  in 300 cc. distilled water, slightly acidify with acetic acid, and then add 10 g. of  $\text{Co}(\text{NO}_3)_2 \cdot 6 \text{ H}_2\text{O}$ . Allow the solution to stand for 24 hours and filter if necessary. As the solution does not keep very well, only small amounts should be prepared at a time.

\* Should contain a little free  $\text{HCl}$ . † The solution should contain some free acetic acid.

*Sodium nitroprusside*,  $\text{Na}_2\text{FeNO}(\text{CN})_5 \cdot 2 \text{H}_2\text{O}$ . 10 % solution.

*Sodium phosphate*,  $\text{Na}_2\text{HPO}_4 \cdot 12 \text{H}_2\text{O}$ , **N**. 119 g. in 1 liter.

*Sodium stannite*, prepared as needed by adding to a little  $\text{SnCl}_2$  solution sufficient  $\text{NaOH}$  solution to redissolve the precipitate which first forms.

*Sodium thiosulphate*,  $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5 \text{H}_2\text{O}$ , **N**. 124 g. in 1 liter.

*Stannic chloride*,  $\text{SnCl}_4, \frac{\text{N}}{2}$ . 32.7 g. in 1 liter.

*Stannous chloride*,\*  $\text{SnCl}_2 \cdot 2 \text{H}_2\text{O}, \frac{\text{N}}{2}$ . 56.5 g. in 1 liter.

*Stannous chloride* (for Bettendorff Test). Dissolve 113 g. of  $\text{SnCl}_2 \cdot 2 \text{H}_2\text{O}$  in 75 cc. of conc.  $\text{HCl}$ , and add a few pieces of C. P. tin foil and keep in glass stoppered bottle.

*Starch paste*. Prepared as needed by mixing about 1 g. of powdered starch with a little cold water to form a thin paste and then adding it to 200 cc. of boiling water; boil for a minute, cool, and use. The solution does not keep, owing to the growth of molds. It may be kept for some time, however, if a preservative such as  $\text{CS}_2$  is added.

\* Should contain a little free  $\text{HCl}$ .

**XV.—TABLE EMPLOYED IN THE PREPARATION OF  
STANDARD STOCK SOLUTIONS \***

Group	Substance	Formular Weight	Solubility of Salt in 100 Pts. of Cold Water	Per Cent Metal	Quantity of Salt to be dissolved in 1 Liter to give Strength 1 cc.=100 mg. of Metal
I	AgNO <sub>3</sub> . . . . .	170	v. s.†	63.5	157
	HgNO <sub>3</sub> · H <sub>2</sub> O . . .	280	sol. in pres. of HNO <sub>3</sub>	71.5	140
	Pb(NO <sub>3</sub> ) <sub>2</sub> . . . . .	331	48	62.5	160
	Pb(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · 3 H <sub>2</sub> O.	379	46	54.6	183
II	Hg(NO <sub>3</sub> ) <sub>2</sub> · ½(H <sub>2</sub> O) .	333	sol. in pres. of HNO <sub>3</sub>	60	167
	HgCl <sub>2</sub> . . . . .	271	7.4	74	135‡
	Bi(NO <sub>3</sub> ) <sub>3</sub> · 5 H <sub>2</sub> O . .	484	sol. in pres. of HNO <sub>3</sub>	43	233
	Cu(NO <sub>3</sub> ) <sub>2</sub> · 6 H <sub>2</sub> O . .	295	v. s.	21.5	465
	CuCl <sub>2</sub> · 2 H <sub>2</sub> O . . .	170	120	37	270
	CuSO <sub>4</sub> · 5 H <sub>2</sub> O . . .	249	40	25	400
	Cd(NO <sub>3</sub> ) <sub>2</sub> · 4 H <sub>2</sub> O . .	308	v. s.	36	278
	CdCl <sub>2</sub> · 2 H <sub>2</sub> O . . .	219	140	51	196
	3 CdSO <sub>4</sub> · 8 H <sub>2</sub> O . .	769	v. s.	43.5	230
	As <sub>2</sub> O <sub>3</sub> . . . . .	198	4	75.5	( )§
	Na <sub>2</sub> HAsO <sub>3</sub> . . . . .	170	v. s.	44	227
	Na <sub>2</sub> HAsO <sub>4</sub> · 12 H <sub>2</sub> O .	402	28	18.7	( )¶
	As <sub>2</sub> O <sub>5</sub> . . . . .	230	150	65	153
	SbCl <sub>3</sub> . . . . .	226	sol. in pres. of HCl	53	188
	SnCl <sub>2</sub> · 2 H <sub>2</sub> O . . .	225	v. s.	53	189
	SnCl <sub>4</sub> · 5 H <sub>2</sub> O . . .	350	v. s.	34	294
	SnCl <sub>4</sub> . . . . .	260	v. s.	46	218

\* Taken from Baskerville and Curtman's *Qualitative Chemical Analysis*, New York, 1910.

† Very soluble.

‡ This amount readily dissolves in 1 liter of water containing 50 g. of NaCl.

§ 33 g. in 1 liter HCl (1:1) gives strength 1 cc. = 25 mg. As.

¶ 267 g. in 1 liter will give strength 1 cc. = 50 mg. As.

**XV. — TABLE EMPLOYED IN THE PREPARATION OF  
STANDARD STOCK SOLUTIONS — *Continued***

Group	Substance	Formular Weight	Solubility of Salt in 100 Pts. of Cold Water	Per Cent Metal	Quantity of Salt to be dissolved in 1 Liter to give Strength 1 cc. = 100 mg. of Metal
III	$\text{Al}_2(\text{SO}_4)_3 \cdot 18 \text{H}_2\text{O}$ .	666	107	8.1	( )*
	$\text{AlCl}_3 \cdot 6 \text{H}_2\text{O}$ . .	242	74	11.1	( )†
	$\text{Al}(\text{NO}_3)_3 \cdot 8 \text{H}_2\text{O}$ .	261	v. s.	10.3	970
	$\text{Cr}_2(\text{SO}_4)_3 \cdot 18 \text{H}_2\text{O}$ .	716	v. s.	14.6	690
	$\text{K}_2\text{Cr}_2(\text{SO}_4)_4 \cdot 24 \text{H}_2\text{O}$	1000	20	5.2	( )‡
	$\text{Cr}(\text{NO}_3)_3 \cdot 9 \text{H}_2\text{O}$ . .	400	v. s.	13	770
	$\text{CrCl}_3 \cdot 6 \text{H}_2\text{O}$ . . .	266.5	v. s.	19.6	570
	$\text{FeSO}_4 \cdot 7 \text{H}_2\text{O}$ . . .	278	60	20	500
	$\text{Fe}(\text{NO}_3)_3 \cdot 9 \text{H}_2\text{O}$ .	404	v. s.	14	715
	$\text{FeCl}_3 \cdot 6 \text{H}_2\text{O}$ . . .	270	v. s.	20.7	482
	$\text{Ni}(\text{NO}_3)_2 \cdot 6 \text{H}_2\text{O}$ . .	291	50	20	500
	$\text{NiCl}_2 \cdot 6 \text{H}_2\text{O}$ . . .	238	v. s.	25	400
	$\text{NiSO}_4 \cdot 7 \text{H}_2\text{O}$ . . .	280	106	21	475
	$\text{Co}(\text{NO}_3)_2 \cdot 6 \text{H}_2\text{O}$ . .	291	v. s.	20	500
	$\text{CoCl}_2 \cdot 6 \text{H}_2\text{O}$ . . .	238	v. s.	24.5	407
	$\text{CoSO}_4 \cdot 7 \text{H}_2\text{O}$ . . .	281	50	21	475
	$\text{MnSO}_4 \cdot 4 \text{H}_2\text{O}$ . . .	223	123	25	400
	$\text{MnCl}_2 \cdot 4 \text{H}_2\text{O}$ . . .	198	150	28	360
	$\text{Mn}(\text{NO}_3)_2 \cdot 6 \text{H}_2\text{O}$ .	287	v. s.	19	527
	$\text{ZnSO}_4 \cdot 7 \text{H}_2\text{O}$ . . .	288	135	22.5	445
	$\text{Zn}(\text{NO}_3)_2 \cdot 6 \text{H}_2\text{O}$ .	298	v. s.	22	455
	$\text{ZnCl}_2$ . . . . .	136	v. s.	48	208
IV	$\text{BaCl}_2 \cdot 2 \text{H}_2\text{O}$ . . . .	244	41	56	179
	$\text{Ba}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot \text{H}_2\text{O}$ .	273	63	50	200
	$\text{Sr}(\text{NO}_3)_2 \cdot 4 \text{H}_2\text{O}$ . .	284	40	31	324
	$\text{Sr}(\text{NO}_3)_2$ . . . . .	212	39	41.3	242
	$\text{SrCl}_2 \cdot 6 \text{H}_2\text{O}$ . . . .	266	106	33	304
	$\text{CaCl}_2$ . . . . .	111	v. s.	36	278
	$\text{Ca}(\text{NO}_3)_2 \cdot 4 \text{H}_2\text{O}$ .	236	v. s.	17	590

\* 620 g. in 1 liter will give strength 1 cc. = 50 mg. Al.

† 450 g. in 1 liter will give strength 1 cc. = 50 mg. Al.

‡ 192 g. in 1 liter will give strength 1 cc. = 10 mg. of Cr.

**XV.—TABLE EMPLOYED IN THE PREPARATION OF  
STANDARD STOCK SOLUTIONS—*Concluded***

Group	Substance	Formular Weight	Solubility of Salt in 100 Pts. of Cold Water	Per Cent. Metal	Quantity of Salt to be dissolved in 1 Liter to give Strength 1 cc.=100 mg. of Metal
V	MgSO <sub>4</sub> · 7 H <sub>2</sub> O . .	246	77	9.7	( )*
	Mg(NO <sub>3</sub> ) <sub>2</sub> · 6 H <sub>2</sub> O .	256.5	200	9.4	1060
	MgCl <sub>2</sub> · 6 H <sub>2</sub> O . . .	203.5	365	11.9	837
	NaCl . . . . .	58	35	40	250
	Na <sub>2</sub> HPO <sub>4</sub> · 12 H <sub>2</sub> O .	358	9.3	13	( )†
	NaNO <sub>3</sub> . . . . .	85	80	27	371
	KCl . . . . .	75	32	52	192
	KHSO <sub>4</sub> . . . . .	136	v. s.	28.5	350
	KNO <sub>3</sub> . . . . .	101	31	39	257
	NH <sub>4</sub> Cl . . . . .	53	33	34	294
	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> . . . .	132	76	27.5	365
	NH <sub>4</sub> NO <sub>3</sub> . . . . .	80	200	22.5	445
	(NH <sub>4</sub> ) <sub>2</sub> HPO <sub>4</sub> . . .	132	36.5	27.5	365
	LiCl . . . . .	42	80	16.7	600
	LiNO <sub>3</sub> . . . . .	69	48	10	( )‡

\* 515 g. in 1 liter will give strength 1 cc. = 50 mg. Mg.

† 77 g. in 1 liter will give strength 1 cc. = 10 mg. Na.

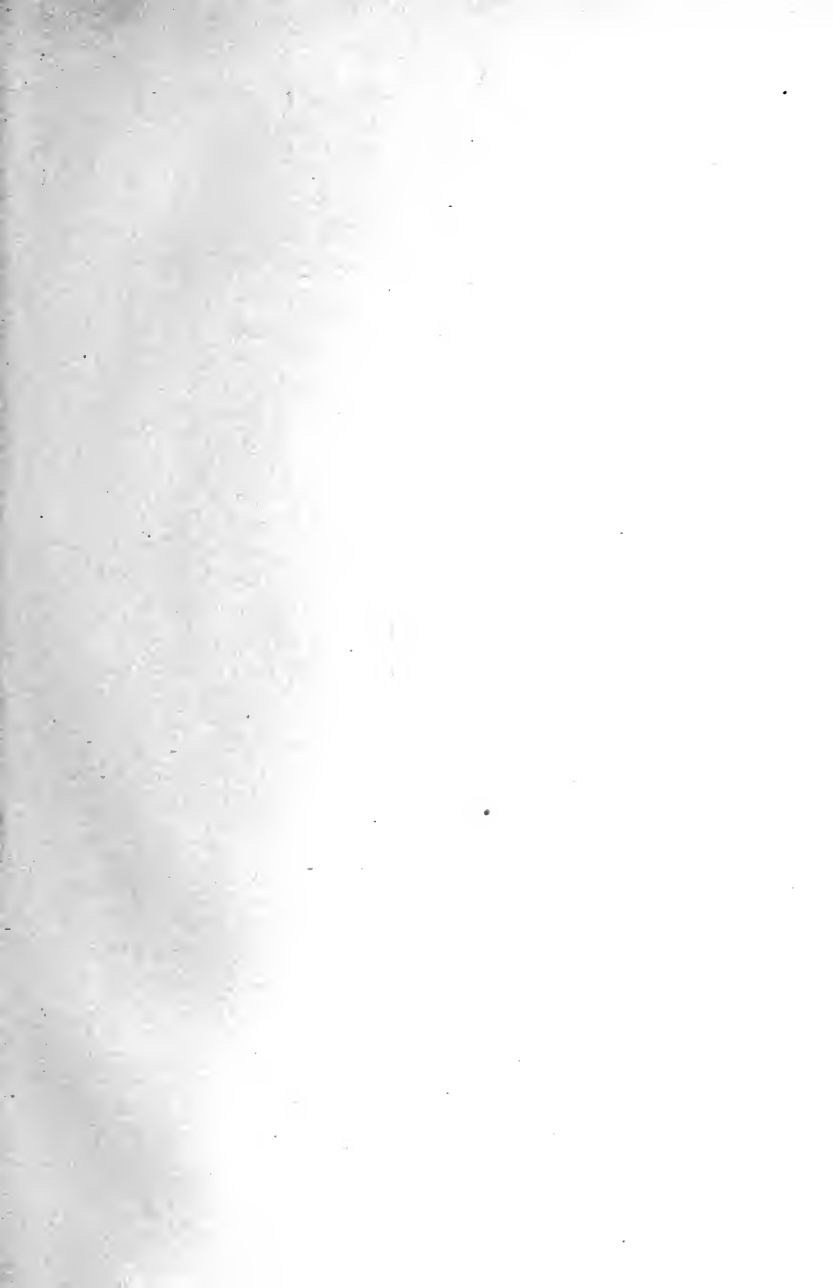
‡ 500 g. in 1 liter will give strength 1 cc. = 50 mg. Li.

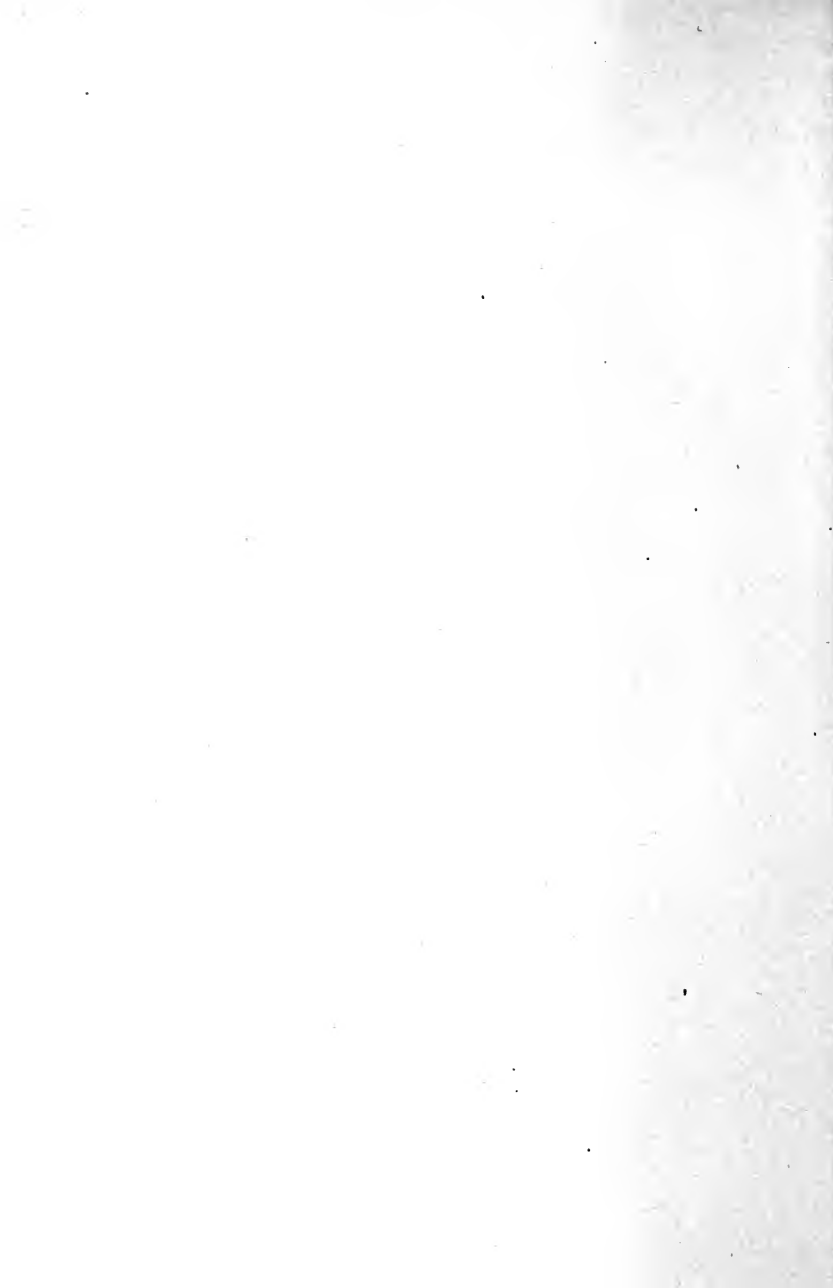
**XVI.—COMPARISON OF CALCULATED AND OBSERVED  
DECOMPOSITION VOLTAGES OF VARIOUS AQUEOUS  
SOLUTIONS**

	Chloride		Bromide		Iodide		Sulphate		Nitrate	
	Calculated	Observed	Calculated	Observed	Calculated	Observed	Calculated	Observed	Calculated	Observed
Magnesium . .	3.28	3 1		2.56		2.01	3.91		3.83	
Zinc . . . .	2.11	2.11	1.65	1.79	1.07	1.25	2.31	2.35	2.23	
Cadmium . . .	2.03	1.9	1.63	1.58	1.06	1.12	1.95	2.03	1.87	1.98
Aluminium . .	2.33	2.0	1.74	1.53	1.02	.88			1.10	
Iron . . . . .	1.78	1.6		1.30		.68	2.03		1.95	
Cobalt . . . .	1.66	1.43		1.05		.51	1.91	1.92	1.84	
Nickel . . . .	1.62	1.33		.85		.36	1.89	2.09	1.81	
Tin . . . . .	1.76	1.61		1.30		.71				
Lead . . . . .	1.80	1.63	1.40	1.33	.87	.83			1.48	1.52
Copper . . . .	1.43	1.32	1.09	1.02	.71	.64	1.22		1.14	
Silver . . . .	1.28	1.11	.99	.95	.60	.65	.44		.365	.36*
Antimony . . .	1.32	1.22		.80		.44				
Bismuth . . . .	1.31	1.21		.92		.43				
Hydrogen . . .	1.71	1.31	1.23	.94	.57	.52	1.70	1.67	1.81	1.69

The observed decomposition values of the acids given under hydrogen, together with many of the sulphates and nitrates, are taken from LeBlanc's *Electro-Chemistry*, pp. 247–248. The other observed values are from Crocker, *Trans. Am. Inst. E. E.*, 1885, p 281.

\* Experiment.











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B31 Progressive problems in  
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